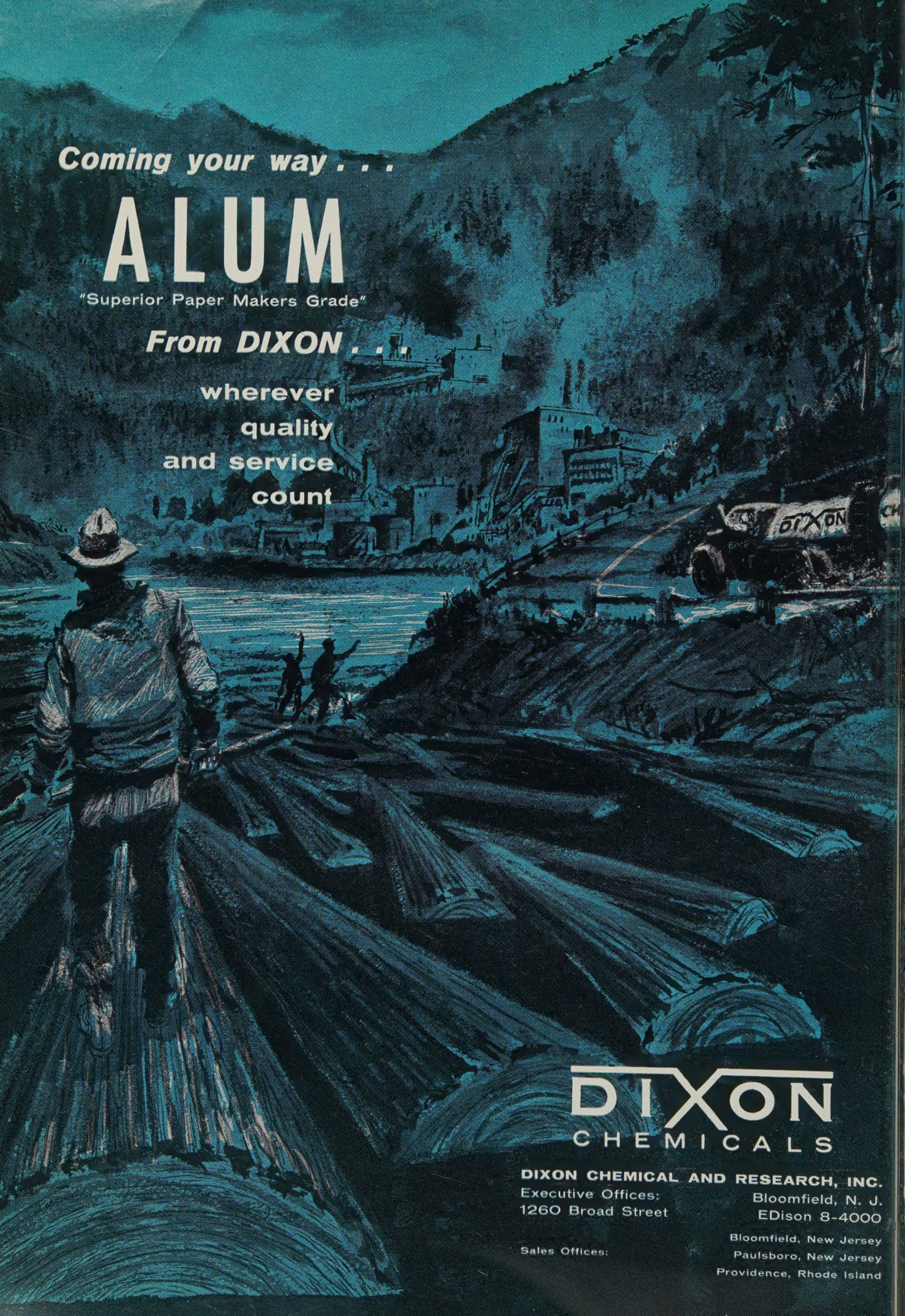
Tappi

THE JOURNAL OF THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

FEBRUARY 1960

VOLUME 43 • NUMBER 2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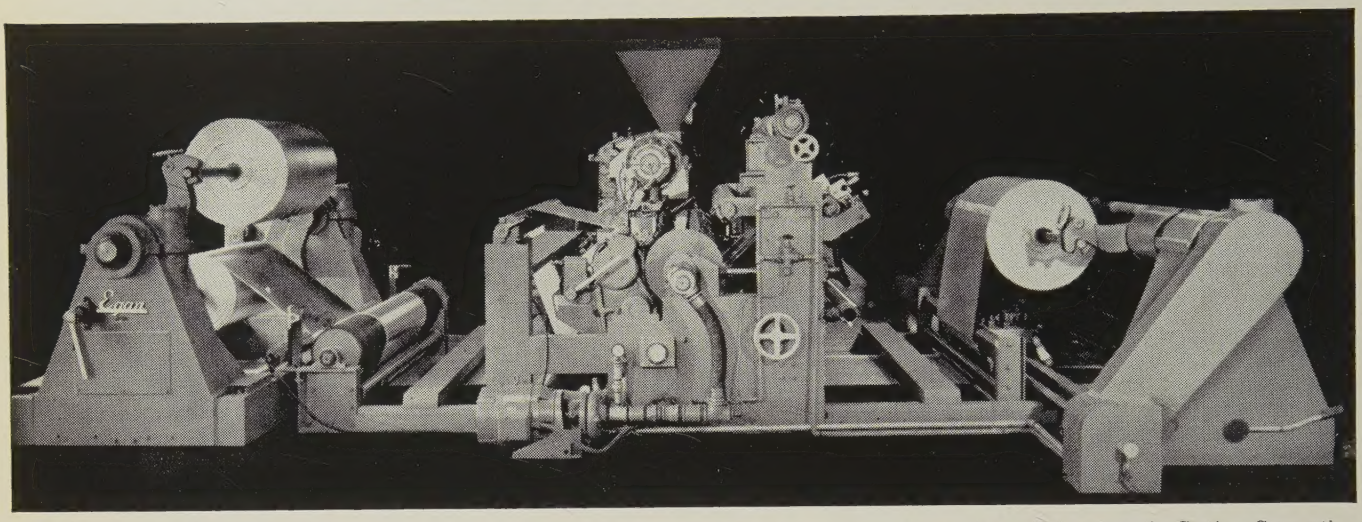
This is a sample of 4-color process lithography on Alpha Protein-processed paper

why an Egan extrusion coater?



Above unit installed at Protective Coatings Corporation, Clifton, New Jersey

One minute's reading time tells you why!

Egan is the world's leading manufacturer of extrusion coating equipment. Eighty-five percent of all companies operating extrusion coater-laminators rely on Egan field-tested equipment.

The extruder itself is a proven, dependable, high-capacity, low maintenance unit. Barrel thickness is calculated for optimum heat transfer. Inexpensive high watt-density ceramic resistance heater bands provide fast heat-up, and *improve* your plant's power factor (ceramic heater bands are economical to buy *and* operate).

The center fed, single piece die minimizes dead storage areas and leakage. Rectangular construction lends itself to more even heating without warpage. Standard or extended die jaw designs are available.

Critical parts of the extruder and die are precision manufactured to close tolerances, permitting accurate gauge control and production of thinner films.

A specially designed double-shell internal spiral chill roll, furnished with mirror or matte finish, assures maximum heat transfer rates for cooling the laminate uniformly (less than 2° F differential across roll). It further permits use of smaller diameter cooling rolls which reduces trim losses, the largest single factor in production waste.

Various laminator designs can be furnished, depending upon the substrate to be handled. Open construction of the laminator permits maximum access and visibility by the operator.

Packaged water circulating and trim disposal systems are also provided.

In addition, patented horizontal and vertical adjustments of the laminating nip, which are essential for obtaining maximum adhesion, are included.

A variety of unwinds and winders can be furnished, depending upon individual requirements (from hand-splice operations to automatic flying splice and flying transfer equipment).

In short, Egan gives you the complete machine package, manufacturing both the extruder and the web handling equipment.

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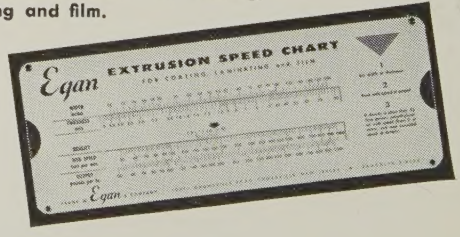

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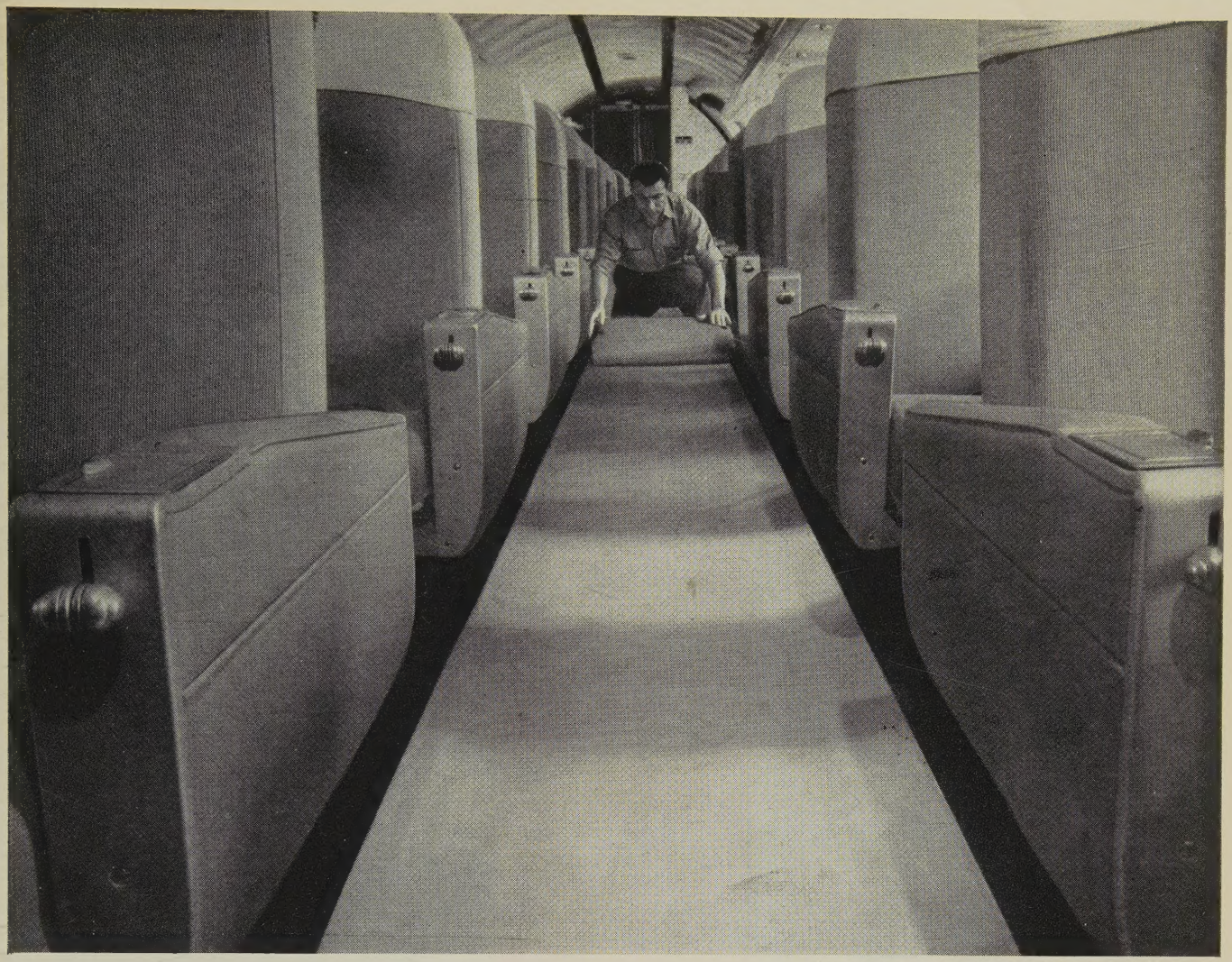

Photo courtesy American Sisalkraft Corporation, Attleboro, Mass.

PLIOLITE LATEX helps protect "flying carpets" from busy ground crews!

Covering aircraft carpeting becomes necessary when maintenance crews must work inside the plane. Would *paper* serve the purpose? Airlines thought so—*providing* it would not stain the carpet—was tough enough to take plenty of scuffing and scraping – flexible enough to permit easy handling—and, of course, low in cost.

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PLIOLITE LATEX does more than provide a permanent bond between reinforcing fibers and paper plies; it also assures outstanding moisture-vapor resistance. Other reasons for using this nonstaining Goodyear latex: uniform high quality—excellent flexibility—and complete compatibility with the resins in the adhesive.

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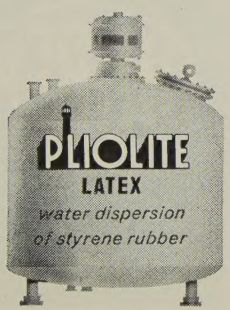

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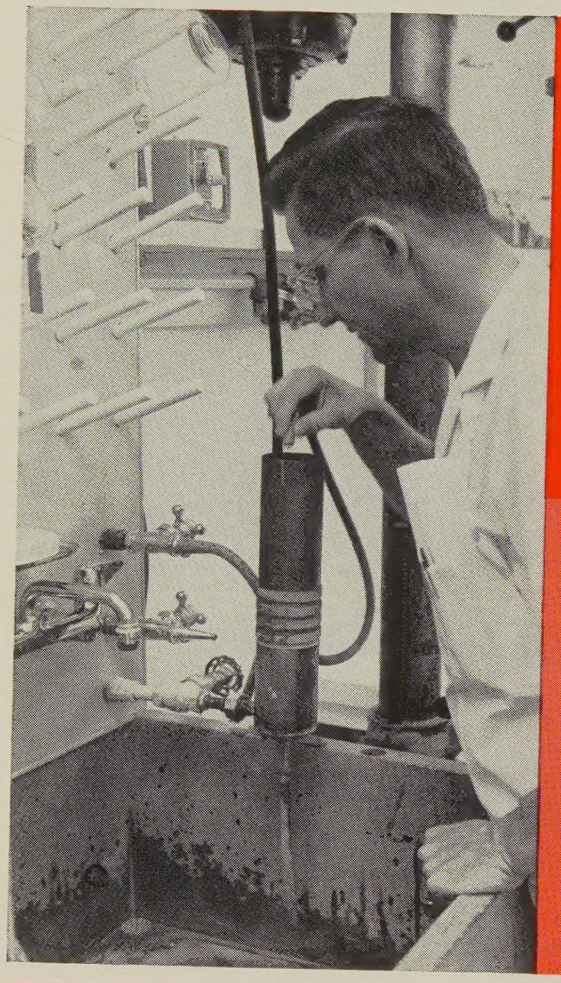
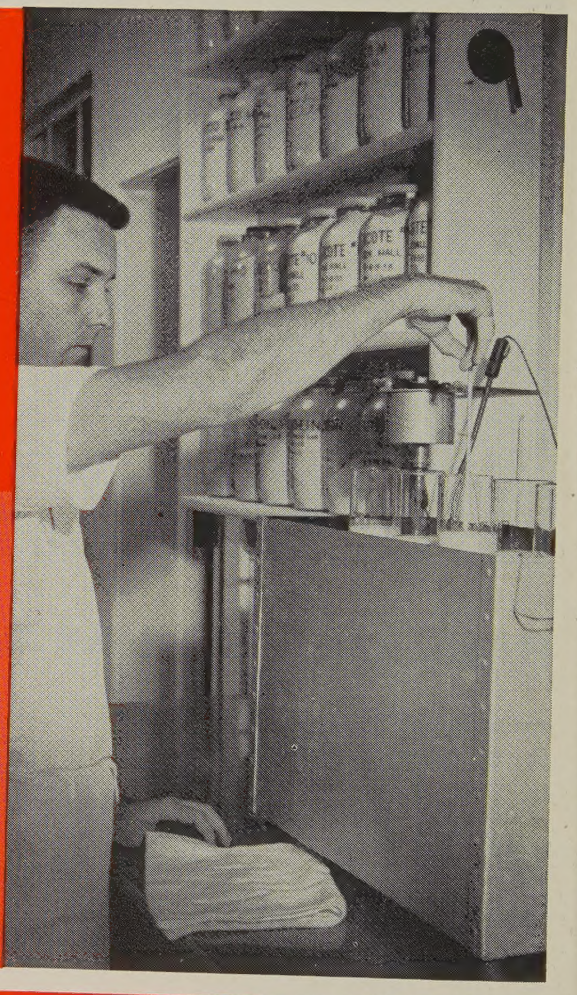


COMPREHENSIVE STUDY of oversized particles *(left)* using a nest of several screens: namely, 80, 170 and 325 mesh. (TAPPI Standard Procedure T645m)

PARTICLE SIZE TESTS, using a hydrometer method *(right)*, determine particle distribution to about one micron. Analysis of finer particles is made with special centrifuges.



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Eleventh Coating Conference
Edgewater Beach Hotel, Chicago, Ill.
May 23–25, 1960.

pulp Bleaching Conference
Edgewater Beach Hotel, Chicago, Ill.
June 14–16, 1960.

Fourteenth Alkaline Pulping Conference
Multnomah Hotel, Portland, Ore.
Aug. 22–24, 1960.

Forest Biology Conference
Seattle, Wash.
Aug. 24–27, 1960.

Eleventh Testing Conference
Pantlind Hotel, Grand Rapids, Mich.
Sept. 27–29, 1960.

Tenth Corrugated Containers Conference
Royal York Hotel, Toronto, Canada
Oct. 10–13, 1960.

Fifteenth Plastics-Paper Conference
Hotel Syracuse, Syracuse, N. Y.
Oct. 17–19, 1960.

Fifteenth Engineering Conference
Robert Meyer Hotel, Jacksonville, Fla.
Oct. 24–28, 1960.

Please refer to Local Section Activities for the locations and dates of Section meetings

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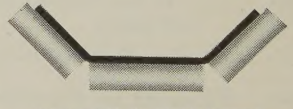

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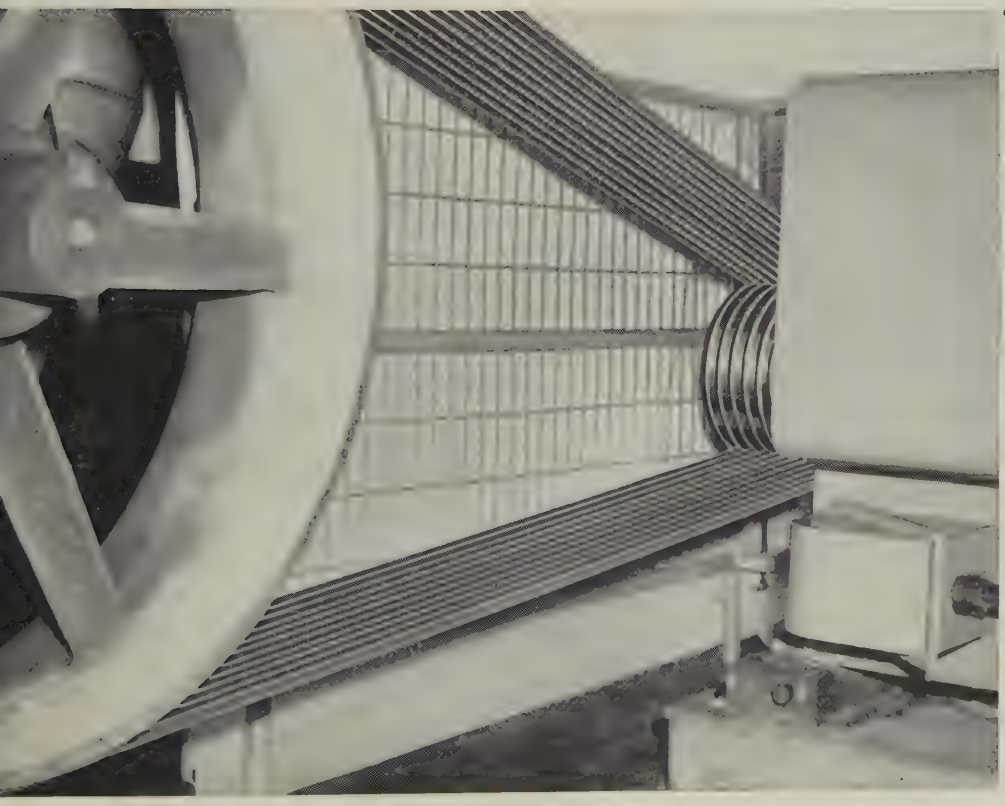

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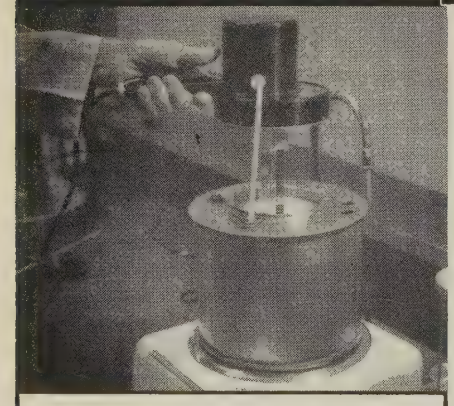

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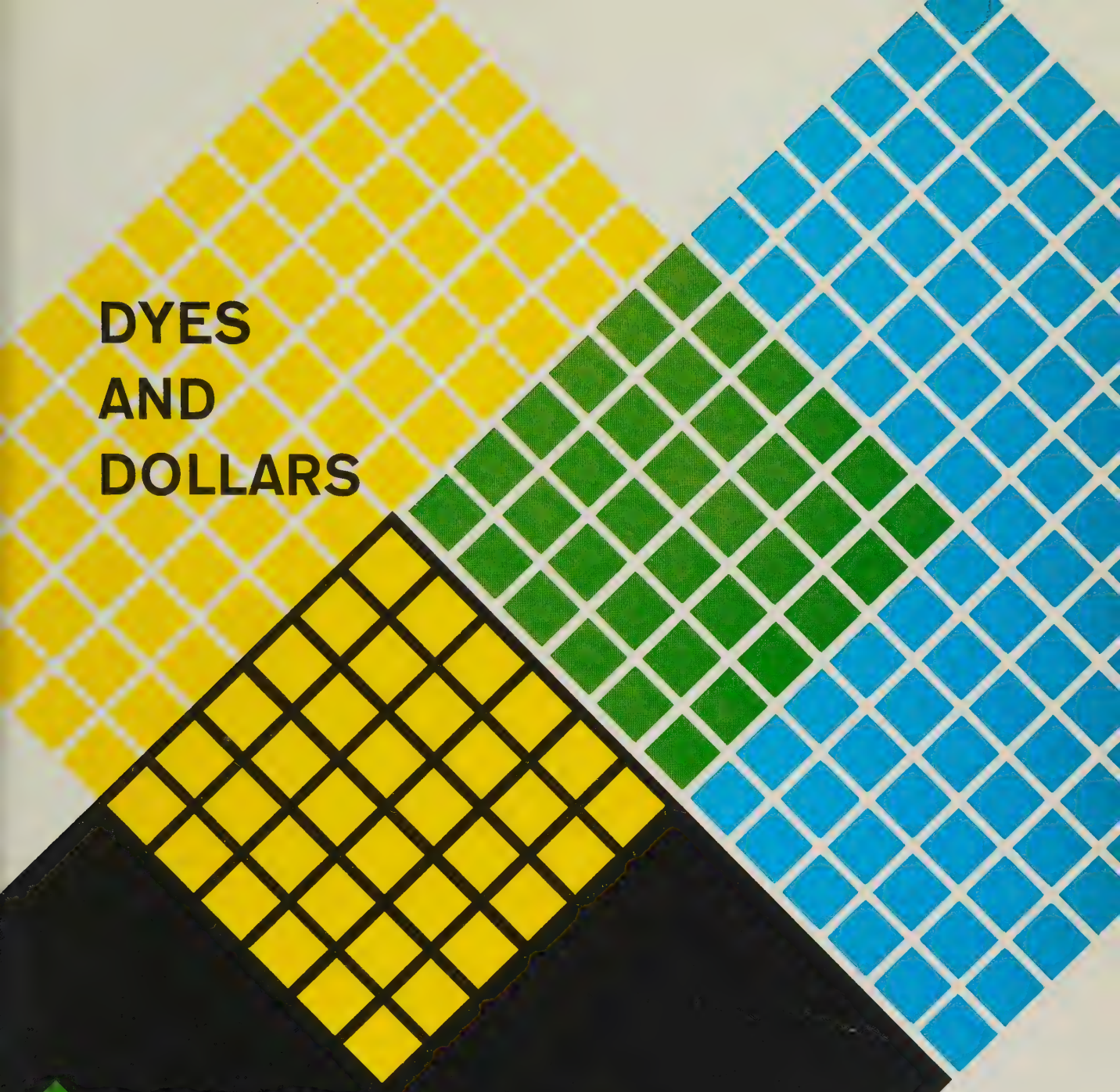

The Color of Money. Paper mills, like other businesses, are always on the lookout for ways to save money without sacrificing quality standards. In the past year CIBA Company Inc. has introduced "Paper-Proved" Dyes aimed at doing just this. Among these are: Direct Yellow P-CD, Direct Yellow P-RCD, Chlorantine Fast Blue P-8GLL.

Your inquiries are invited on CIBA "Paper-Proved" technical information, samples and color matching.

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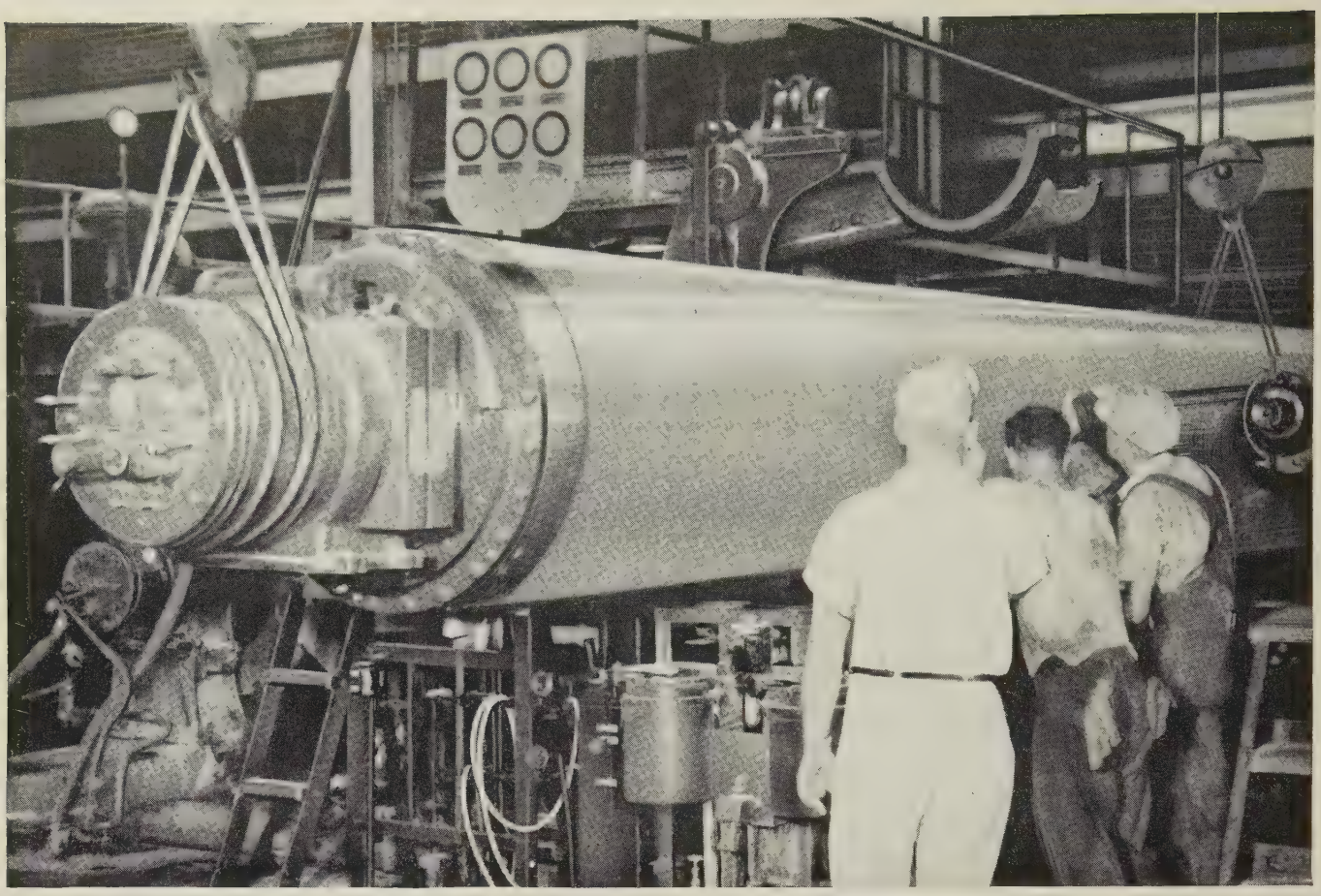
Direct Yellow P-RCD

Chlorantine® Fast Blue P-8GLL

All three are versatile dyes, recommended for bond, ledgers, mimeo, offset printings and specialty convertings. In addition, these dyes have excellent light-fastness and good fastness to acids, alkalis and water. Bleaching with hypochlorite permits the use of the broke in other light shades. Pleasing shades of blues, yellows and greens can be obtained for facial, toilet and napkin stocks.

CIBA

CIBA Company Inc., Paper Chemicals Department



World's largest. Shown during its installation at Union Bag-Camp Paper Company, the world's largest Monel alloy press roll is 240-inches long, 36-inches diameter, 1⅞-inches wall. It was formed of 3 Monel nickel-copper alloy plates cold pressed to shape and welded longitudinally. With Monel alloy, large weldments are readily produced.

MONEL press roll now in 5th year!
STILL NO PLUGGING OF SUCTION HOLES!

...at yearly inspections little or no grinding has proved necessary

It takes courage to break tradition.

But engineers of Union Bag-Camp Paper Company knew what they were about when... in 1954... they had this big suction press roll fabricated of Monel* nickel-copper alloy.

The record of this Monel alloy roll speaks for itself.

① **No plugging to date.** Suction holes remain free of fibre build-up and slimes. Have yet to be reamed. With rolls of traditional alloys, plugging had proved particularly severe when producing wet-strength paper.

② **Minimal regrinding of surface.** The resistance of Monel alloy to macro-etching by corrosive solutions has proved outstanding. Nearly always, roll is returned to service after routine inspections without regrinding.

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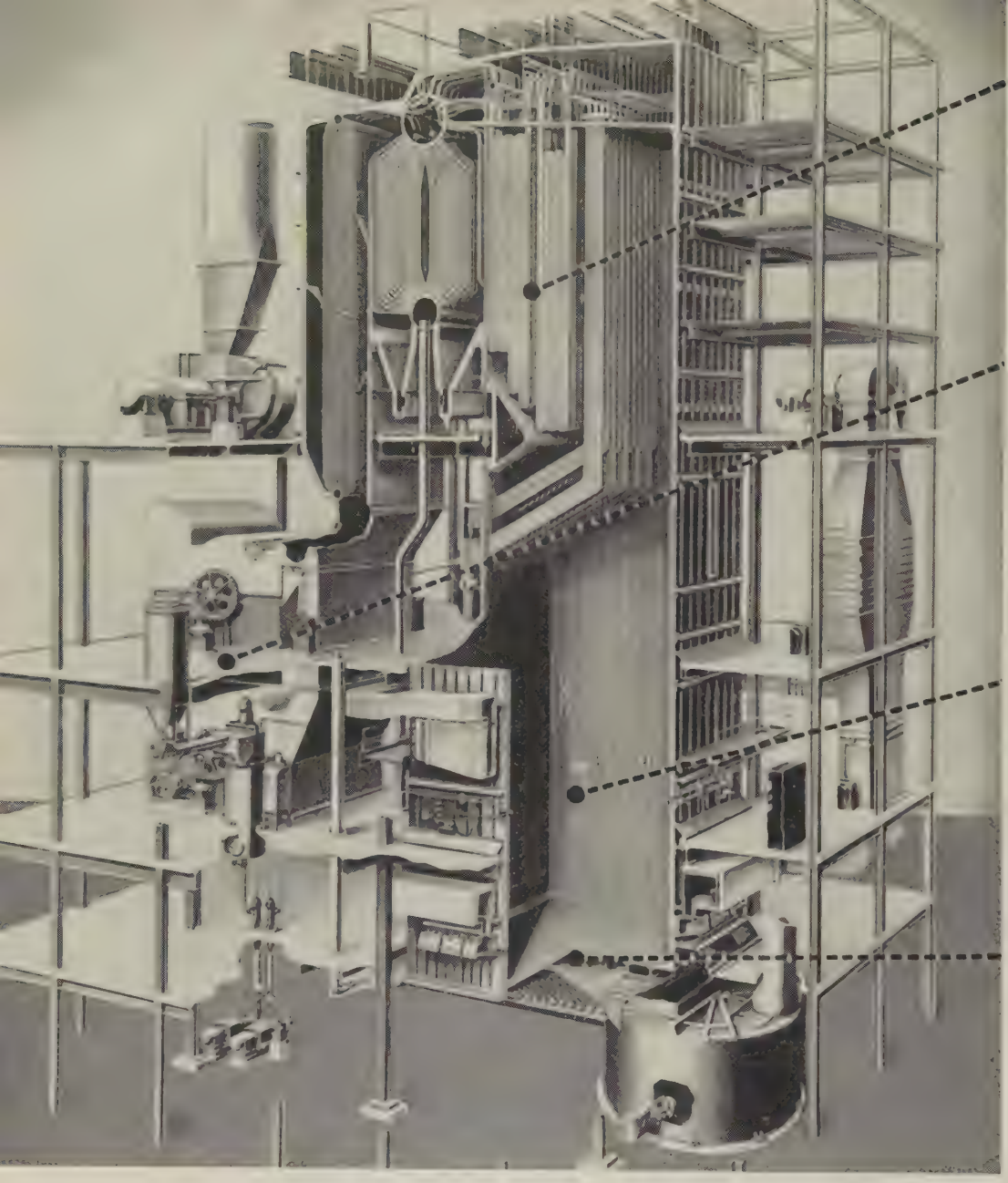

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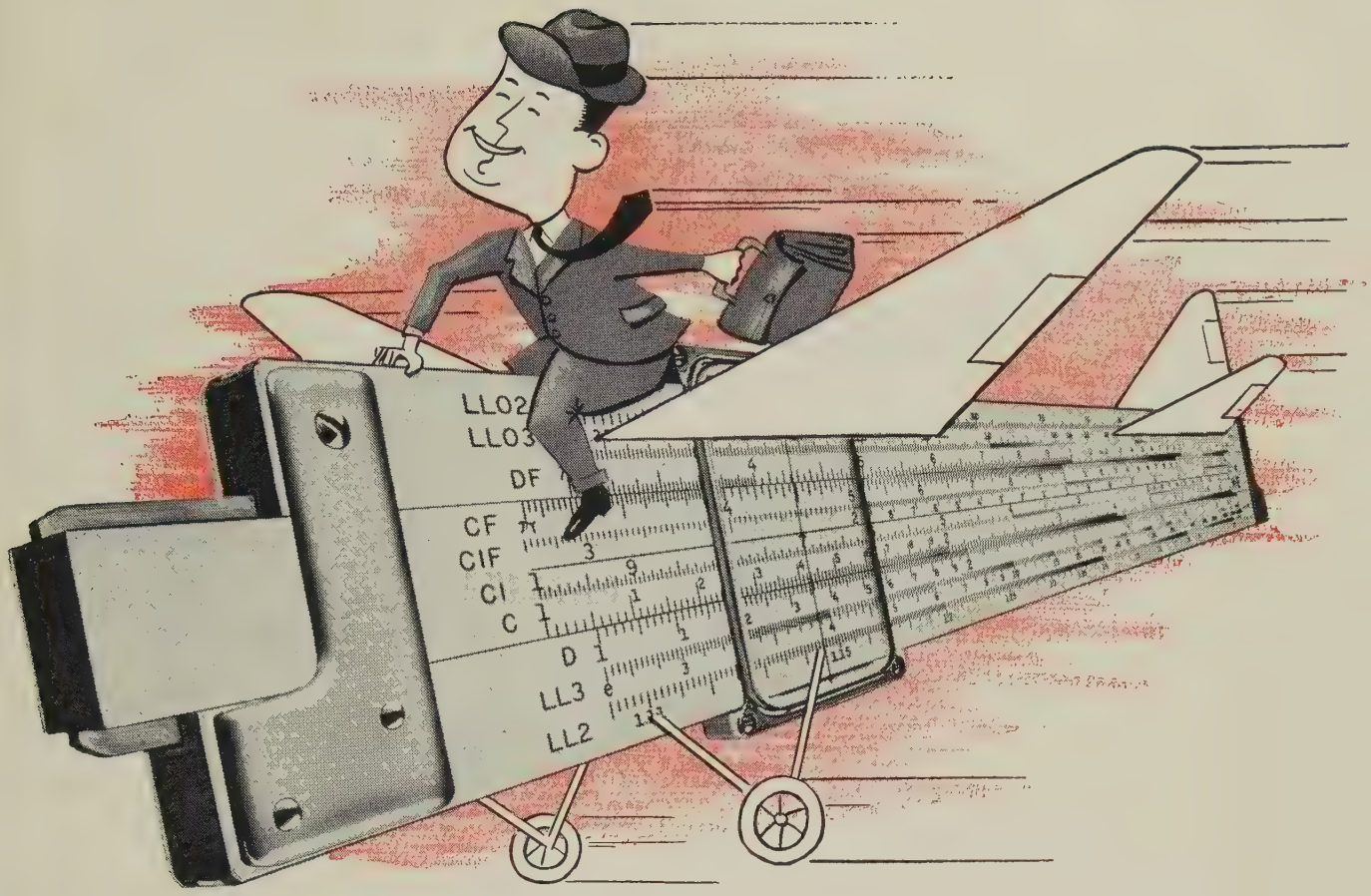

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Do You Really Mean It?

J. E. ANGLE

It is a pleasure to be with you this morning and to bring you greetings from the largest steel-producing center of the world. At first glance, it might seem that the two industries, paper and steel, have very little in common. A little thought will reveal several points of mutual interest. For instance, both industries depend in large part on a continuing and economical supply of natural raw materials which require long-range planning to develop and deliver to the point of consumption. Perhaps you are familiar with some of the research and exploration that has been conducted by the steel industry since the war to provide new sources of iron ore. With respect to the paper industry, every one should be familiar with the magnificent job you have done in developing and conserving timber resources.

Another point in common which might interest you comes to mind from my early days in sheet and tin plate production. The conversion of the manufacture of steel sheets from a hand-batch process to the continuous strip method began in earnest as we were coming out of the depth of the depression. New equipment had to be designed, first, to produce wide strip continuously, and then to cut it into sheet lengths and pile it for shipment. Some of the original design ideas were adapted from paper-handling equipment. We have appreciated the help we received at that time. I suppose we have one other characteristic in common: it requires mountains of printed matter to get our work done! Incidentally, I hope you are not anticipating that I can give you a solution to the latter problem. All I can suggest is that you take a course in how to increase your reading speed; perhaps then you can keep even. Basically, however, I believe American industry has many common interests and problems, and that much experience and knowledge are transferable from one field to another. It is because of that conviction that I agreed to discuss certain matters with you today.

A number of years ago, I happened to become involved in a discussion with a high-school principal on the subject of the academic standards maintained in the system of which his school was a unit. He made the observation that most of the students did not want to excel in their studies, but preferred to do average work, and moreover he agreed with their attitude. He said that if a student happened to do "A" work, he was ostracized by his fellows, and since popularity and social acceptance were more important than academic achievement, he was quite in sympathy with their attitude.

I took issue with him on several counts, of course, but essentially on the grounds that one never achieves average by setting one's sights at that level. Very rarely do we accomplish as much as we set out to do, and consequently if we aim to do "C" work, the chances are that we will score "D" or lower.

Although I do not pretend to be an expert on education, I am, by reason of being the father of four, more than a casual observer of the academic scene. It is disturbing to note among my circle of youthful acquaintances a reluctance and even a resistance toward excellence in any endeavors save those where popular acclaim is assured, such as athletics, automobiles, jazz, or the more spectacular aspects of science. Generalizations based on a small sampling are dangerous, but in support of my observation, let me call to your attention a speech made by Dr. Charles Malik, President of the General Assembly of the United Nations, before the Midwinter Personnel Conference of the American Management Association in Chicago on Feb. 18, 1959. He was speaking on "Human Relations and the Industrial Order." Among other things, he said, "In a fundamental sense, certainly all men are born equal and certainly they are entitled by nature to the enjoyment of inalienable rights. But there is such a thing as excellence in workmanship and excellence in moral character, and we are certainly not all equally excellent in these respects." And then he continues, "Sloppiness in workmanship is the curse of this age. People in the past slaved to produce perfect works of art much more than they do now. They are in a hurry today, they are practical, they have their minds much more on their rights and enjoyments than on their work,—their hands shake, their eyes are moist, their minds are misty, and they do not love their work. Human relations in the industrial order will not improve until people, in place of worshipping themselves, worship the objective standard of excellence of their work. Again, what is wanted is pride in excellence and not in mere being."

I have quoted Dr. Malik because I think he is a competent observer of the world scene and his remarks are pertinent to the situation found in many countries.

By this time, you are no doubt wondering whether you have gotten into the wrong room and what the connection may be between industrial engineering, education, and the pulp and paper industry. Frankly, I would not attempt to draw an analogy between what I have just described and the situation in your own field. It may be that what I have on my mind is entirely inappropriate and inapplicable to your industry. As a general rule, however, I think it safe to say that nothing is perfect and that everything we do can be done better if we put our minds and energies to it.

If one could state an objective for the entire American industrial community, I think it would be:

"To produce the best possible product at the lowest possible cost and at the highest profit that is consistent

J. E. Angle, Vice President—Industrial Engineering, United States Steel Corp., Pittsburgh, Pa.

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with sound management and the public good." No doubt some of you may stumble a bit over that part about the public good, but I would prefer not to debate it at the moment beyond the point of asking whether it can be ignored. On the other hand, I hope you will agree that it is our job in industry to produce the best possible product at the lowest possible cost, and to do these things at an adequate profit, however that may be defined.

If you do agree, then we are around to the subject of my talk: "Do You Really Mean It?" Are you aiming to do "A" work or are you satisfied with something less? Are you using all the tools available to you or only those you have used for the last ten years? Or to pin-point the situation more precisely, as I see it, are you confronting your problems squarely, defining them correctly, and then making the decisions necessary to give you a complete solution? I ask these questions because I have a rather deep-seated suspicion that is not subject to proof that we in American industry make far too many compromises in the solution of problems, either because we do not have all the facts or because we are unwilling to fight through to the right answer.

For example, we all subscribe to the idea that where a machine can do a task that has heretofore been done by hand, it will do it better because it can work to closer tolerances and is not subject to human error. It follows, then, that machine-made products should be better than those hand-made, but are they? You all know the answer: some are and some are not. Does not the fact imply that there is a certain deficiency in our American system of production when we do not consistently produce the highest quality goods at any given price?

Moving from generalizations to a more specific area, certainly the problem of growing competition from foreign producers, not only in world markets but here at home is well known to all of us. A common example, of course, is that of the Japanese buying logs in the Unites States, shipping them to Japan, converting them to plywood, and exporting them to us at delivered prices far below the domestic price. They are also buying steel scrap in this country and returning it to us in the form of finished steel at similar price differentials.

What are we to do in the face of such competition? Should we erect tariff walls to keep out foreign goods? Experience in the past has proved that high tariffs only result in reciprocal tariffs designed to keep our products out of their markets. Furthermore, tariff protection has a tendency to slow down progress in the protected industries. When the sharp spur of competition is withdrawn, we all tend to take it easy. Say what you will, protective tariffs engender a sense of security, false though it may be, and too much security can put us to sleep.

In my opinion, the only sound answer to competition, foreign or otherwise, is to beat the competitor on his own field: to make a better product at the same price or an equal product at a lower price. And I don't think this has to be done through cutting wages here. Obviously, we must achieve stability in wage rates in this country if we are ever going to compete. The inflationary binge in which we have been indulging since the war, and to which unjustified wage increases have contributed, is just like dope. You feel fine, and everything seems rosy while at the same time body, mind, and character are deteriorating.

On the other hand, no responsible producer has any thought that taking away labor's gains or reducing our standard of living is either a practical or proper answer. As a matter of fact, I think American industrial management has been proud that we could pay high wage rates and still compete. Now, however, the resurgence of foreign industrial capacity, assisted by American capital and know-how, has put us to the test.

How can we meet it? Or perhaps the question should be put more positively by asking "How will we meet it?"

The answer to the problem of survival in a competitive world economy will be found, not surprisingly, in people who rise to the challenge, and by people I refer specifically to management. In saying this, I am not ignoring the contribution which will continue to be made by the engineers and scientists who have developed the marvelous new machines and the techniques for using them that are now at our disposal. In fact, the majority of such people are an important part of the management structure. The proper and effective use of the new technology, however, will depend in large part on executive management and how well it can integrate and organize to take full advantage of it.

Let us take a look for a moment at some of the more important developments that have come about in recent years. One of the most significant can be termed the whole field of information or systems. Terminology varies, depending on how close one is to the subject, but what I am thinking about includes the electronic data processing machines and computers, along with the mathematical skills that are required to employ them in the solution of massive problems. Associated, too, are the less spectacular, but none the less important, developments in the processing of routine information needed for costs, inventory control, order processing, and transportation. In the future, these inventions will have a tremendous impact on how we manage.

Another major scientific achievement, which in the long term will materially change our economy, is the development of nuclear energy for peacetime use. To forecast what this effect will be is beyond my ability and would serve no particular purpose today. It is enough to point out that nuclear energy has already generated a whole new industry and will in time be a factor with which management as a whole must reckon. Incidentally, I might remind you that the first commercial nuclear power plant is located at Shippingport near Pittsburgh and feeds electric energy into the power pool which supplies the city of Pittsburgh.

Automation, so-called, is not new if it is assumed to mean the substitution of electromechanical devices for human effort; but the rapid development and perfection of servomechanisms has reached the stage where their application to practically all phases of production is entirely conceivable. Management must know and be able to evaluate the potential of such things.

Startling advances in communications and trans

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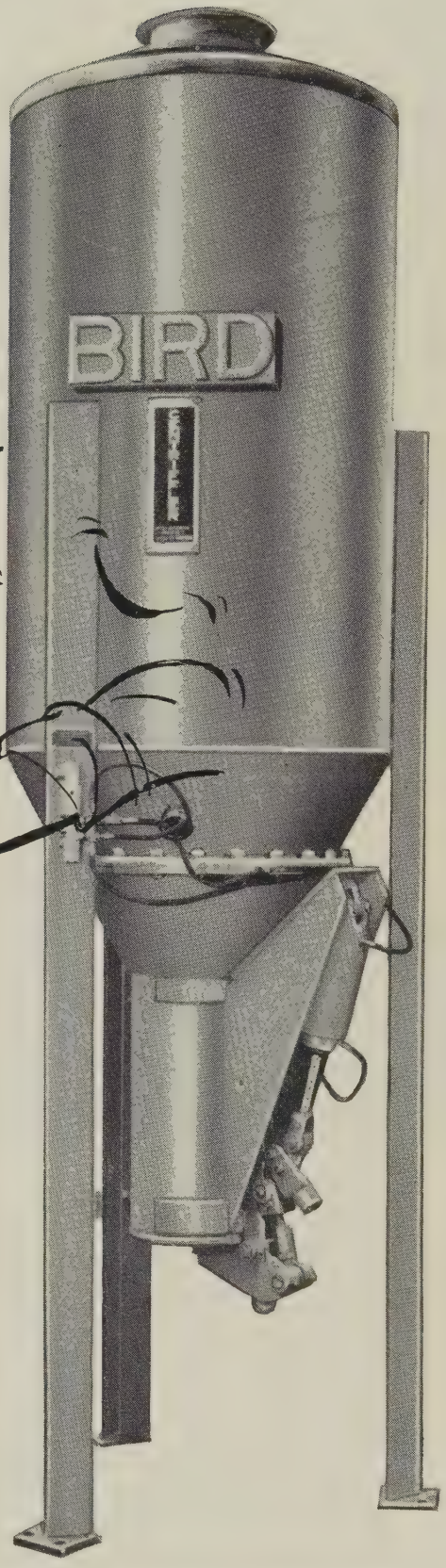

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portation have come about since the war. Not only have time spans been reduced immeasurably, but it has been necessary to revise many concepts hitherto held. Decisions must be made more quickly, things happen much faster. Mass communication is eliminating sectionalism and to some extent sectarianism, and public opinion is a force that can be quickly aroused. Management cannot afford to overlook such developments, but instead must understand and know how to work with them.

Management's job has been further compounded by the emergence of monolithic labor unions in the past twenty years and the power that they give to a relatively few men in our economy. We could point out, also, as Robert Heilbroner does in his book, "The Worldly Philosophers," the increasing tendency for politics and economics to become indistinguishable because the politicians either carry out the recommendations of the economists or change the rules so that economics laws are circumvented. Regardless of which is the case, management must still be able to perform within the environment in which it finds itself.

I cite these developments in order to emphasize how difficult management's job has become. We can also say that the opportunities open to management are becoming increasingly broad, but that in order to capitalize on them, management must be better educated and probably trained along somewhat different lines than have been traditionally followed. You may be interested in reading an article in the Harvard Business Review for November, 1958, written by Harold Leavitt and Thomas Whisler and entitled "Management in the 1980's." In their discussion, they lay great emphasis on the changes that will result from the full utilization of mathematical techniques and computers in information and problem solving. I find it difficult to agree with their conclusions that middle management will be greatly reduced and that to a large extent the decision-making process will be in the hands of the staffs who program the computers. However, I do agree that these developments will change decision-making and that they will have an important impact on the manner in which management operates. In fact, I would predict that the management function will be vastly different 10 years hence than it is now. There will be a higher proportion of management people in the organization than now. The increase will be in the technical staffs primarily, rather than in direct supervision. There will be a larger proportion of employees engaged in clerical and office work than now. Maintenance forces will more nearly equal the production workers. There will be a trend in the direction of centralization, at least in the sense that more decisions will be made in the headquarters office. More time will be devoted to long-range planning and more confidence placed in market analysis and forecasting as these tools become more precise. These effects will have important implications for industrial engineering because, if I am correct in my concept, industrial engineering is in a broad sense that branch of the engineering profession which is concerned with scientific management directed at earning a profit, and specifically charged with constant improvement in the efficiency with which we use our resources of men, equipment, and materials.

In the light of this background, let us examine industrial engineering from the various aspects of its origin and development, its present status, how it can be most effectively used, and what industrial engineers can do to make it the important management tool that it should be.

At the risk of repeating some history that many of you already know, let me sketch the early development of certain ideas which we take for granted today.

So far as can be ascertained, the original concepts of industrial engineering appeared in England early in the Industrial Revolution, but probably because of the secretive attitude of the managements of the period, no publicity was given them, and there is not much evidence that they were generally used. In the United States, the period from about 1880 to 1910 saw much activity in the field of "scientific management." Many individuals, among them H. L. Gantt and Fred and Lillian Gilbreth, made lasting contributions to the development, but the one who is considered the father of Scientific Management was Frederick W. Taylor.

Taylor was an engineer employed initially by the old Midvale Steel Co., where he was first hired as a common laborer and subsequently worked himself up through the machine shop to be chief engineer of the company. He later worked for Bethlehem Steel and following that did consulting work in the line of putting his ideas into practice. He had early deplored the rule-of-thumb methods employed in machine-shop work and especially the fact that the worker himself was largely on his own in determining how the job should be done. He concluded that there should be one best way to do a job and that there should be one best machine or tool to use for the purpose. His experiments, based on this conclusion, were carried out at Midvale and formed the basis for a paper titled "Shop Management," which he presented to the American Society of Mechanical Engineers. Following this work, he expanded his research into other types of operations, both at Midvale and Bethlehem. At several points he utilized some of his observations to develop incentive plans, which were applied with spectacular results. In 1903, he published another paper called "Scientific Management," in which he extends his earlier conclusions to a comprehensive application to any manufacturing process.

Shortly after, there arose a growing reaction on the part of organized labor to the newly-announced concept of "Scientific Management" to the effect that it would be a means of throwing men out of work. When the U. S. Government tried to apply Taylor's principles of management to the Watertown Arsenal, much adverse publicity resulted. Some time later, Louis Brandeis, applying the term "scientific management" to the Taylor system, successfully undermined an appeal of the Eastern railroads for a rate increase on the basis that their use of these principles had reduced their costs to the point that an adjustment was unnecessary.

The controversy over Taylor's system culminated in a Congressional Investigation in 1912. The details are unimportant, but the results were. Scientific-management techniques were prohibited in government installation for a long time; and "scientific

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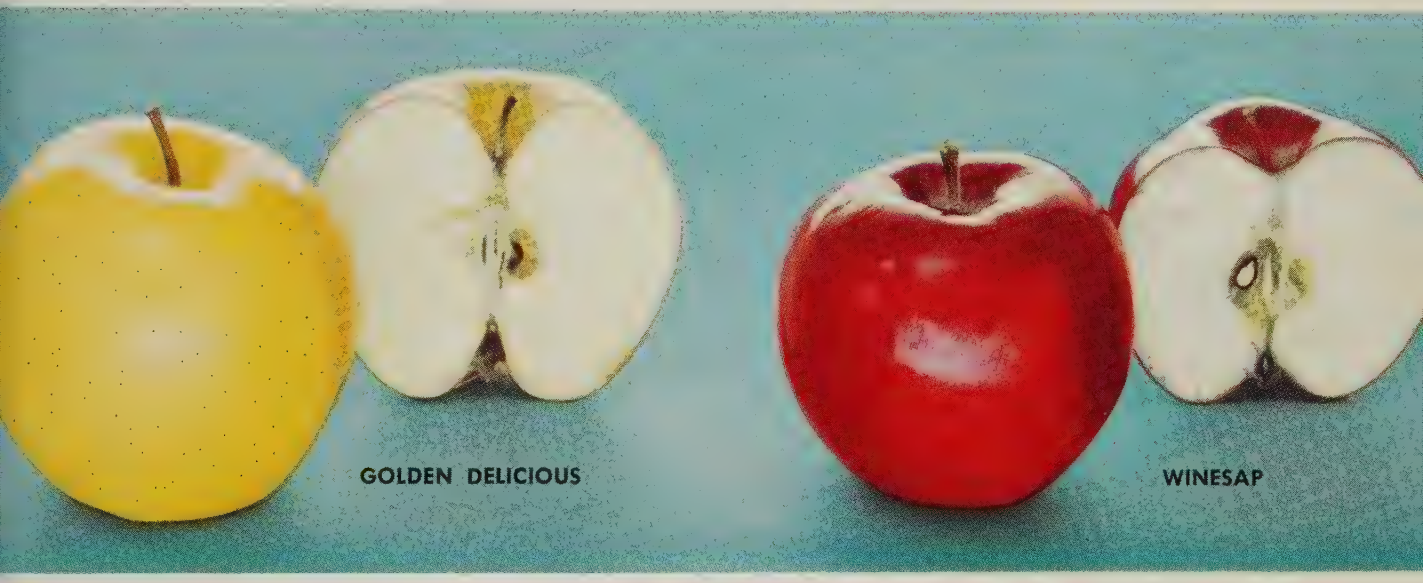

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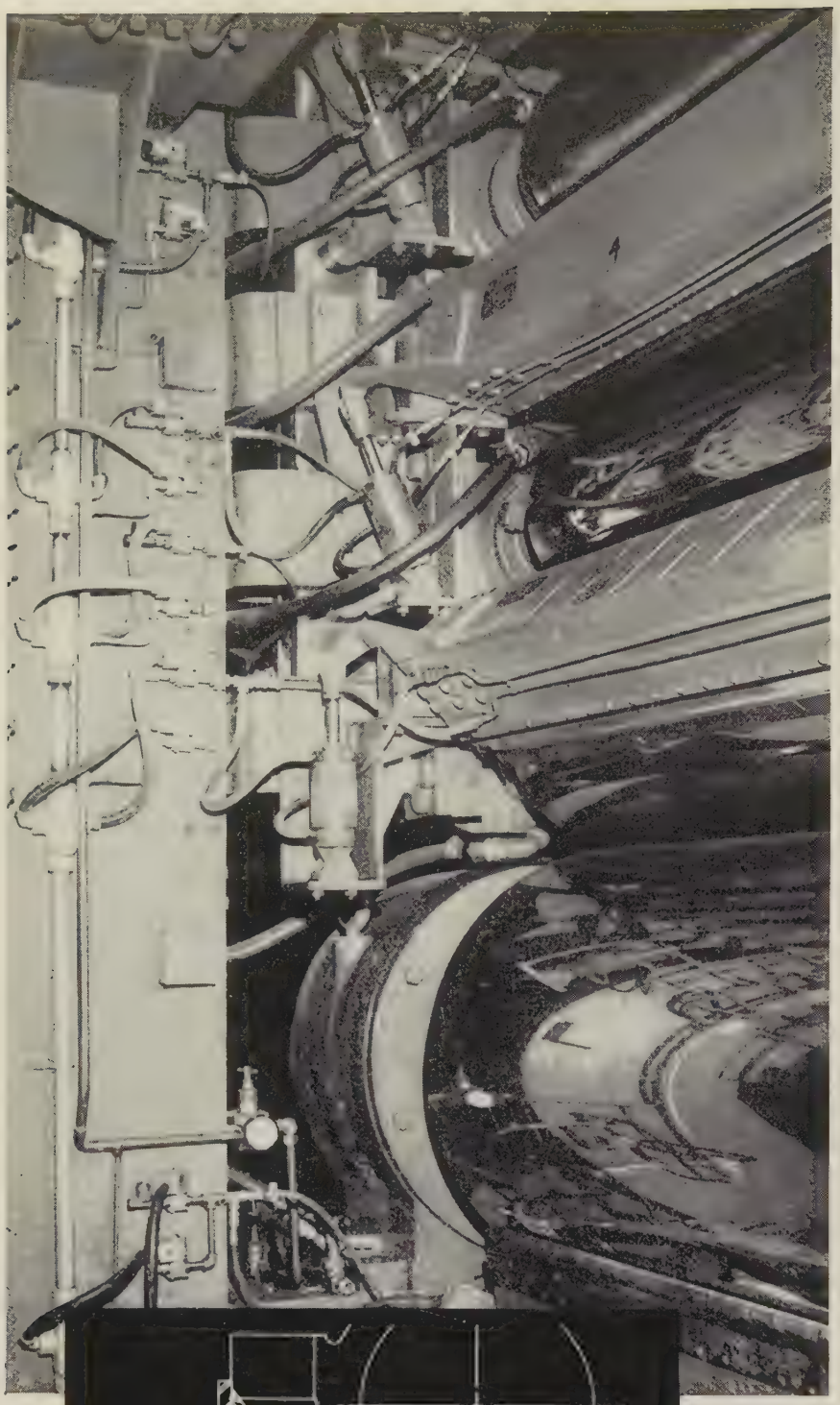

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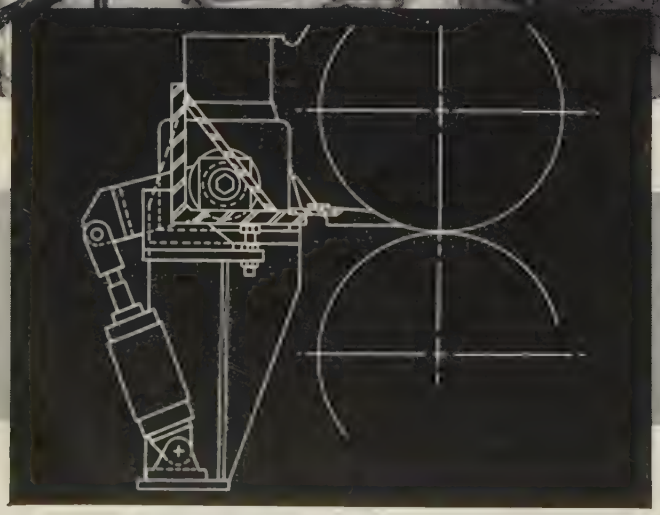

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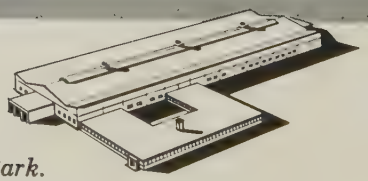

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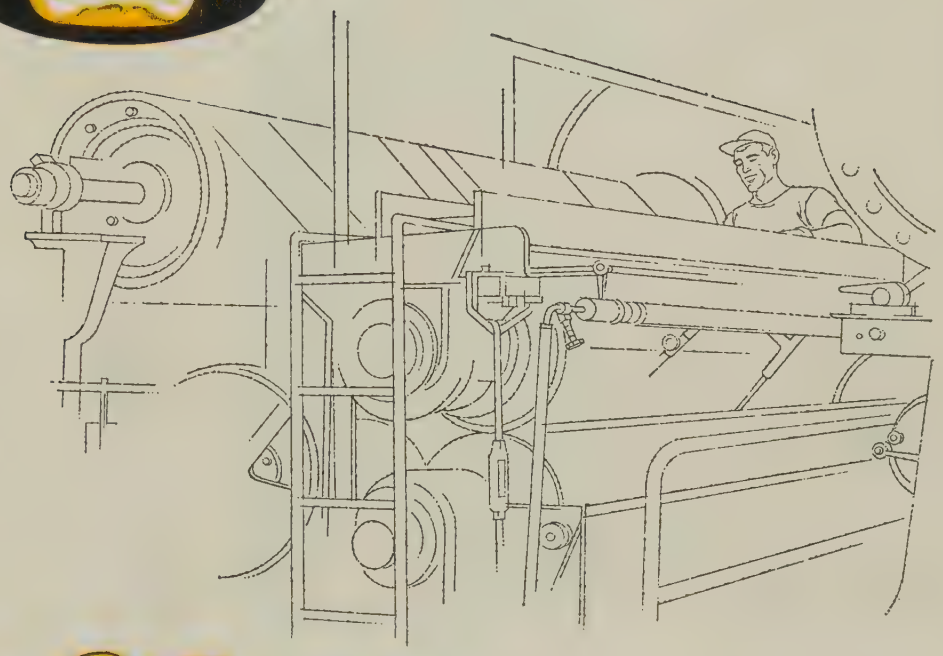

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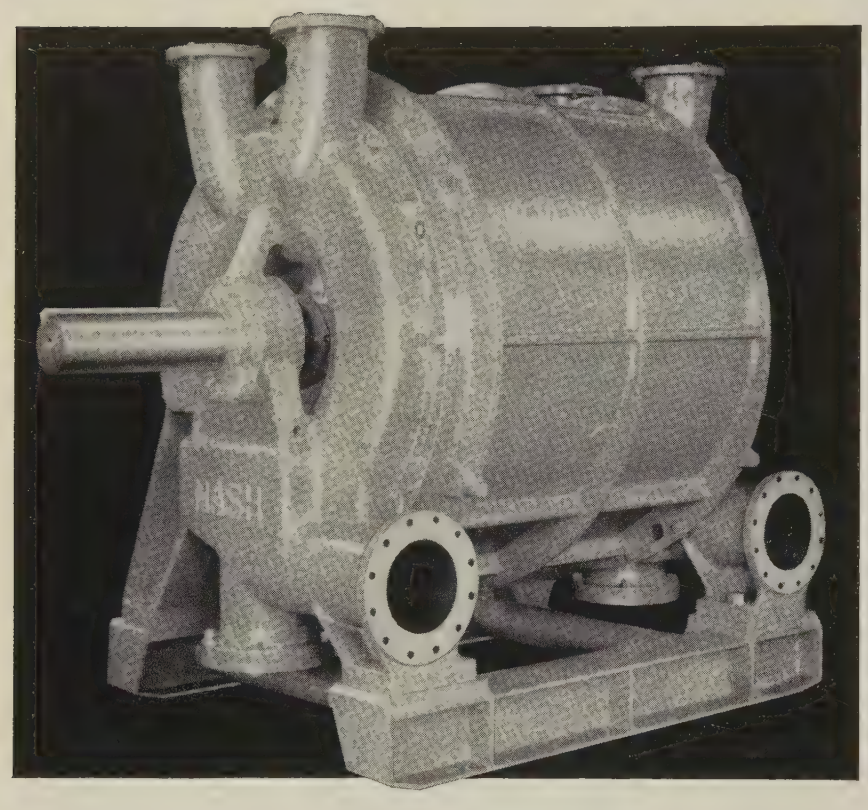

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management" received a black eye and a serious setback, some of which still hangs like a cloud over "Industrial Engineering," because the latter term was adopted as a euphemism, if you please, for "scientific management."

To complete the background, we might take a brief look at what Taylor advocated. The first principle was to develop the task in a scientific manner by analyzing the methods and the equipment, and selecting the best of each; second, to select the best fitted workmen for each job; third, to educate and train the worker in the best method; and fourth, to establish a cooperative effort between management and worker, which would involve, on the part of management, proper planning and smoothing the way so as to make it possible for the worker to produce most effectively. Taylor said that his plan was characterized by science instead of rule-of-thumb; harmony, not discord; cooperation, not individualism; maximum output, not restricted output; and the development of each man to his greatest efficiency and prosperity. The net result, he claimed, would be a greater return to the worker because he would be paid on an incentive basis, a greater gain to the company and to the public because there would be more to share. These principles are still sound, but unfortunately, just as in Taylor's day, we are not completely able to put them into effect.

Most of the early work in industrial engineering was directed at improving the efficient use of labor, and, of course, much of it still is. At the same time, such men as Henry Gantt applied the same techniques of analysis to other management functions, with similar success. For example, Gantt developed order-control and machine-loading systems which are still in use today. Others who followed recognized that scientific management was not necessarily limited to the industrial situation, but had application to city and university management and even hospitals. Unhappily, however, these uses of the new science were not generally recognized, being overshadowed by the more controversial and highly publicized time-study and incentive work.

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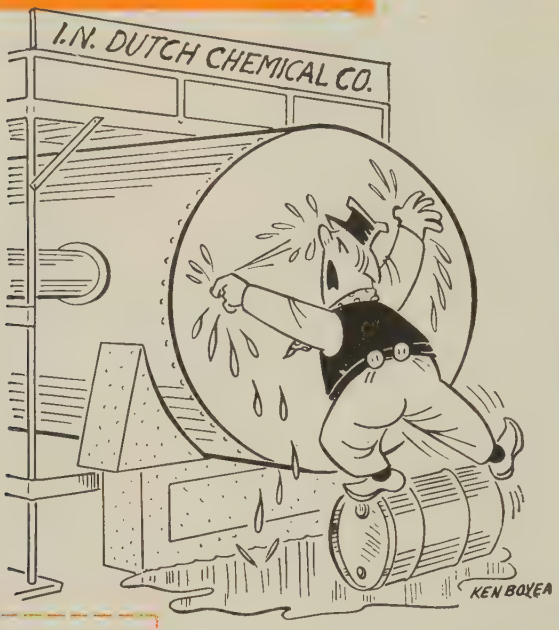

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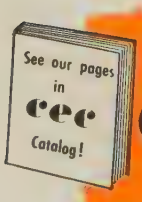

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comprehends a broad range of interests from methods engineering, facility planning and design, to basic standards for cost control and operations research. As taught in our universities, industrial engineering covers many more subjects than these. And yet, if we were to take a representative cross section of American industry, I think we would find that in general the use of industrial engineers is restricted to two or three well-defined functions, such as wage incentives, production control, and cost control, rather than to the full scope of their abilities. This is not to say that the other functions are not being performed, but in many instances they are being done by special groups set up for the purpose, and in some companies they have been assigned to existing staff departments that may not be as well trained in the subject as industrial engineers.

If this is a correct observation, why is it that some managements do not make full and proper use of their industrial engineers? To find the answer to that question, I think we have to recognize first that the damage that was done by adverse publicity 40 years ago still remains with us to a certain extent. It is not that many people actually remember the Watertown Arsenal case, or the report of the Hoxie Committee on "Scientific Management and Labor." It is a fact that attitudes which developed on both sides, management and labor, hardened into philosophies which carried down through the years and to a certain extent still exist. For example, there is still an inbred fear on the part of labor unions that once an incentive plan is established, management will use every opportunity to cut the standards, even though the conditions under which standards may be adjusted are clearly spelled out in the labor agreement. On the management side, the fact that industrial engineering work has so often resulted in trouble has caused many executives to be very reluctant to make extensive use of their services.

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One of the principal reasons why industrial engineers have not been adequately recognized I would attribute to their own shortcomings. Incidentally, some of our universities are doing a splendid job of providing training that will overcome the deficiencies I am about to describe. It is a characteristic peculiar to industrial engineering that much of the work has a direct impact on people, as contrasted to the more or less indirect effects of the work that other branches of engineering perform. Not only this, but the industrial engineer often works in fields where any layman can have opinions. Only a qualified expert would criticize the design of a bridge from the standpoint of its load-carrying capacity, but almost any Joe around the shop has an opinion on how much a job is worth, how it should be done, and what's wrong with the way the plant is run. Consequently, the industrial engineer is confronted with a tough assignment: he must maintain the integrity of his work if he is going to be of the most value, and yet the benefits are not realized until his recommendations are accepted and installed by line management. He cannot work in isolation and hope to come up with practical answers. Regardless of how technical his studies may be, they ultimately have to be expressed in terms and concepts that are understandable and readily administered by those who will be responsible.

Take incentives as an illustration. The time study and calculations that are necessary may be extremely voluminous, but the rate sheets that are handed to the crew should be carried to no more detail than is absolutely necessary. Standards should be averaged into the fewest possible significant groups, and the calculations needed to arrive at earnings should be simplified to the extent that the men covered by the plan can figure their own earnings. Nothing is gained by making incentives more complex than the operation of the plan requires, and much distrust may be generated when the union or the men cannot understand them. I believe that industrial engineers have been prone to take a one-sided view of their work, without considering how it will be received. They have been so precise in small details that they have failed to realize and solve the big problem. In short, they have not used common sense to the extent that their work is consistently practical.

Another fault which I have observed is an undue reliance on the printed word—a tendency to back up their arguments by reference to policy or procedure rather than logic and reason. Industrial engineers are frequently accused of quoting from the book, and I agree. No manager likes to be told that he cannot do a certain thing because the procedure prevents him. In the first place, he is probably quite aware of the procedure. In the second place, he is able to distinguish between policy, which is, in a way, a company's code of ethics, and procedure, which is a time-saving device to assist in policy administration. Procedures are not moral laws, and he has every right to expect his industrial engineer to advise him how to get the job done within policy, not to tell him bluntly that it cannot be done.

There is also a rather irritating proclivity among industrial engineers to develop a language of their own. Here again, we run into the problem that most of our work concerns people. Other branches of engineering deal in standard scientific terms: kilowatts, horsepower, B.t.u.'s, etc. They mean the same the world over, and even though the layman may not understand them, he can find out if he wants to take the trouble. Industrial engineering terms, such as, normal, leveling, memo-motion, M. T. M., are not generally accepted scientific expressions and have meaning only within the fraternity. Many expressions may be peculiar to a particular company or organization—the engineers may speak a language of their own. It is most irritating to an operator to be confused by having a lot of such language thrown at him, only to find out later that it all could have been said in every-day English if the engineer had only taken the trouble to think about it.

Fundamentally, one of the basic faults I find is a tendency to slip into a routine performance of certain assigned responsibilities and a failure to venture into other fields. Don't misunderstand me. I am not recommending empire building—"expanding the work to fill up the time available for its accomplishment." What I am speaking of may have some subtle connection with a subconscious desire for security. The plant engineering staff, for instance, is usually loaded with work all the time. The plant industrial engineer thinks to himself, "How nice it would be to have so much work that no one would ever question the importance of industrial engineering." So he proceeds to establish for his department at every opportunity certain assigned duties which may occupy the majority

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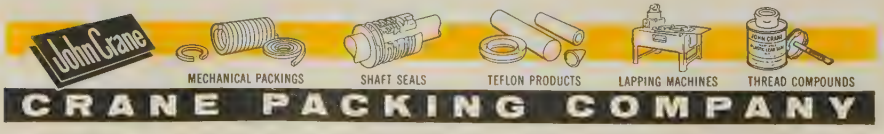

of his staff full time. His people become so tied to a routine that they don't have an opportunity to explore new ideas or develop themselves. They have dug themselves into a deep and endless rut. Furthermore, I think it important that in managing the industrial engineering function we follow a practice of shifting our engineers from time to time. Instead of holding a man to incentive work year after year, move him into cost work after he has had sufficient experience on incentives, and then after that let him show what he can do on methods improvement. We have an obligation to make it possible for every man to develop to his fullest capacity, and that results only when a man faces new challenges.

What I have in mind as the ideal industrial engineering department is a keen, competent, fast-moving group of engineers, who, though they may be responsible for certain regular functions, have latitude to apply their imaginative talents to the performance of such duties and, at the same time, perform a management consulting service at all levels of the organization. When we consider what industrial engineering has to offer, it just isn't good business to relegate it to the position of a high-grade clerical function. An industrial engineer, if properly trained, should have attributes that are not precisely duplicated in any other branch of engineering. His scientific training is sufficiently general that he is not an expert in any one field, and yet he should be able to understand most scientific problems, and upon occasion become well informed in a specialty. He should have more than a speaking acquaintance with modern cost-accounting principles, sound organizational concepts, and an understanding of psychology and labor relations. Most important, he should be trained to be objective in his thinking, because it is this quality which will ultimately determine his value to management. He should have the ability to work constructively in any type of operation from mining to merchandising, from clerical to research. He should have the capacity to be a competant advisor and consultant to all levels in the management structure.

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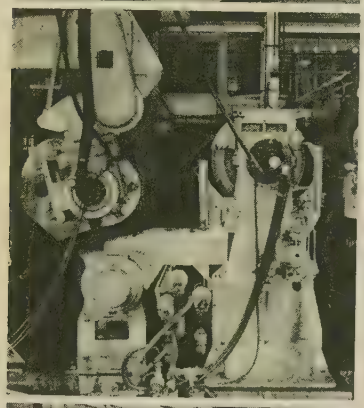

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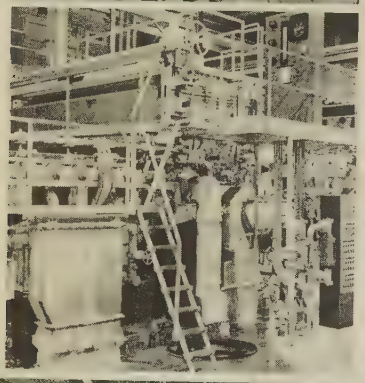

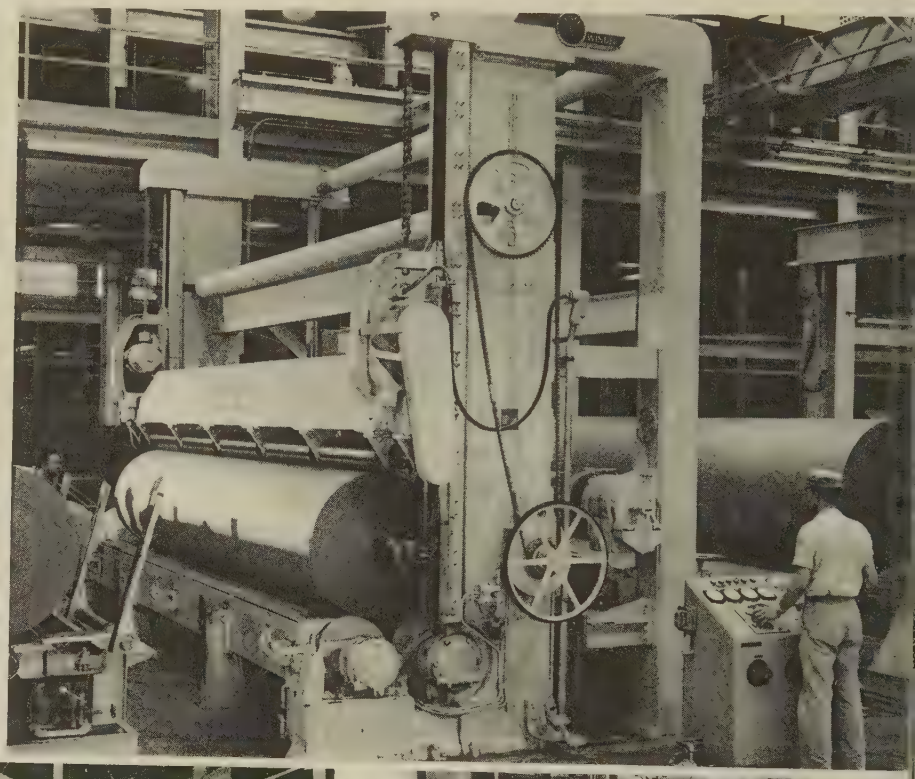

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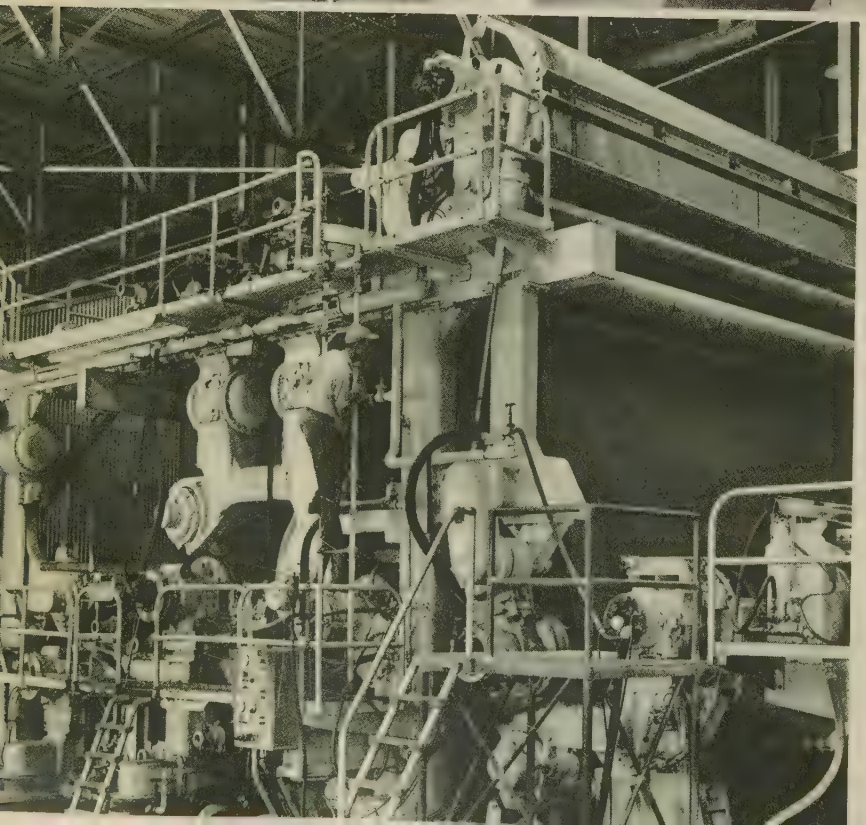

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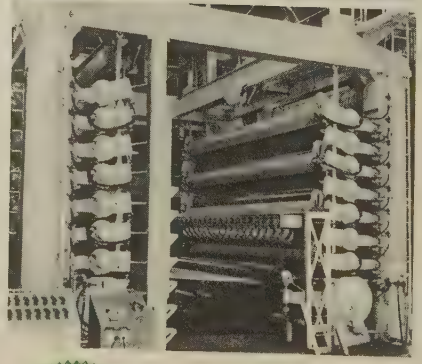

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To find industrial engineers employed in such a broad scope is not the general rule. I have given you some of the reasons why I think this is so. Essentially what is needed is to convince executive management that industrial engineering, used at its fullest capacity, can be a powerful tool for profit improvement. If that is ever accomplished, the demand for industrial engineers will never be satisfied, for American management has never been bashful about making an investment for profit.

How do we create the opportunity to show what we can do? First, we should take a critical look at how we are doing our present job. Are we using our engineers at their proper skill, or are they loaded down with work that any clerk could do? Are we applying the most modern techniques to our work? Do we get jobs done promptly? Do our reports look like finished projects—well arranged, neatly reproduced, appropriately bound? How does our department look to an outsider? Is it businesslike, well organized, efficiently run? Are we sufficiently flexible that we can take on a special assignment without upsetting the routine?

Second, we should talk about what we can do—not in the manner of braggarts, but with confidence in our ability. Communications upward are just as important as communications down the line, and they are practiced a lot less skillfully in many organizations. It is part of your job to let the boss know how you can perform a more constructive service for the company. Ask for an opportunity—suggest an idea—present a well-thought-out proposal.

Third, deliver the goods. Whether it's a project you initiated or an assignment he handed you, do it well and do it promptly. Use all the facilities at your disposal, including other staff services. If in doubt, check your results with your peers in the organization, but when you go back to your superior, hand him a complete, clear, and practical recommendation ready to go into operation. If you have done your work well, you will get more opportunities.

Let me give you my views on how the industrial engineering function should be managed and the more important areas in which it should work. Assuming an industrial enterprise, the chief industrial engineer or director should be in a staff position relative to the operating line and should be at a level at least equivalent to other operating staff heads. This not only makes him available to the operating executive, but also confers sufficient prestige to the function to enable it to carry on effectively. If the enterprise is large and comprises decentralized divisions and plants, industrial engineering positions should be similarly located at the various manager levels, and preferably reporting to the local operating executive. Experience indicates that the industrial engineer should be part of the local operating organization, even though policy guidance and administrative advice may come from the headquarters staff.

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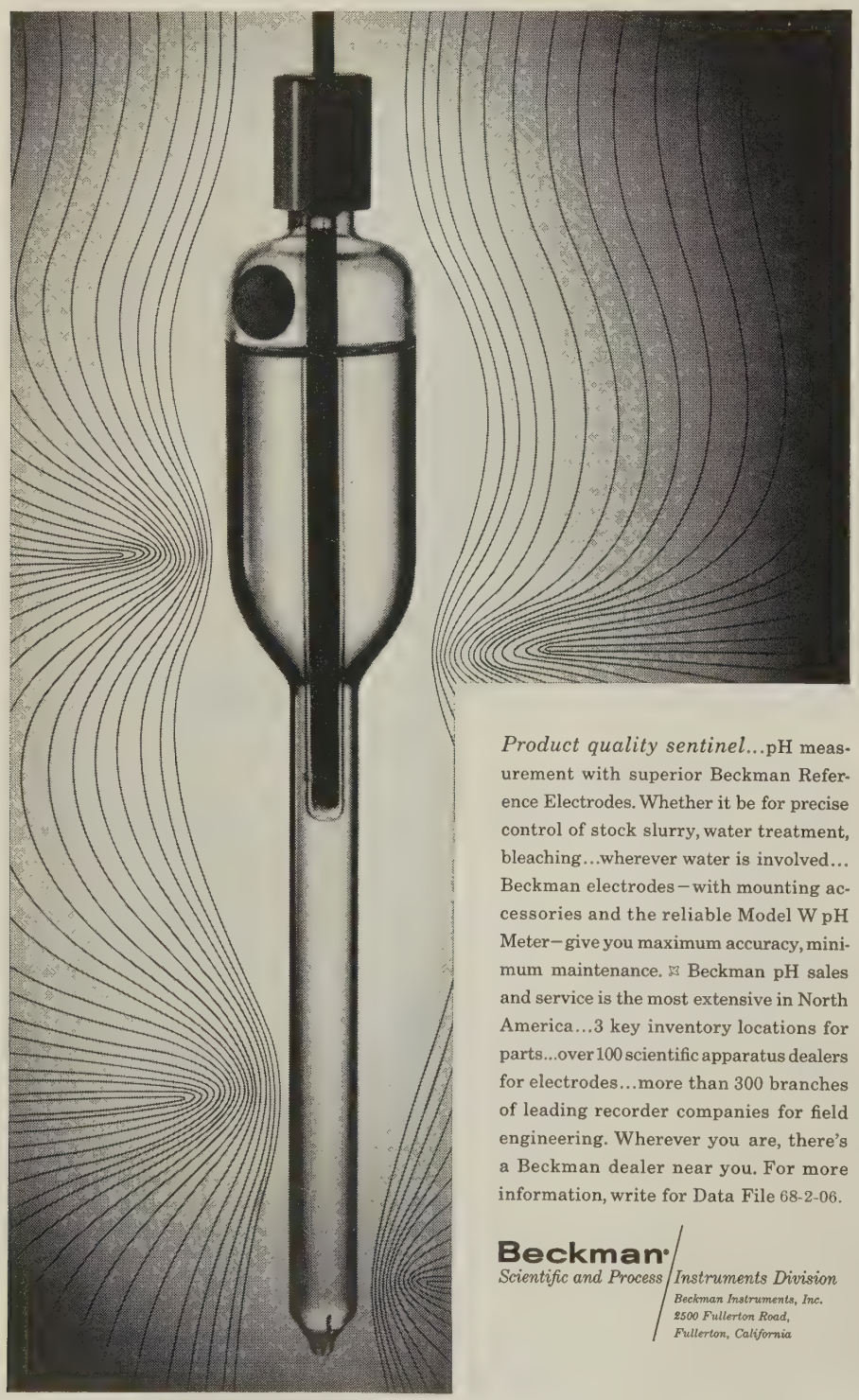

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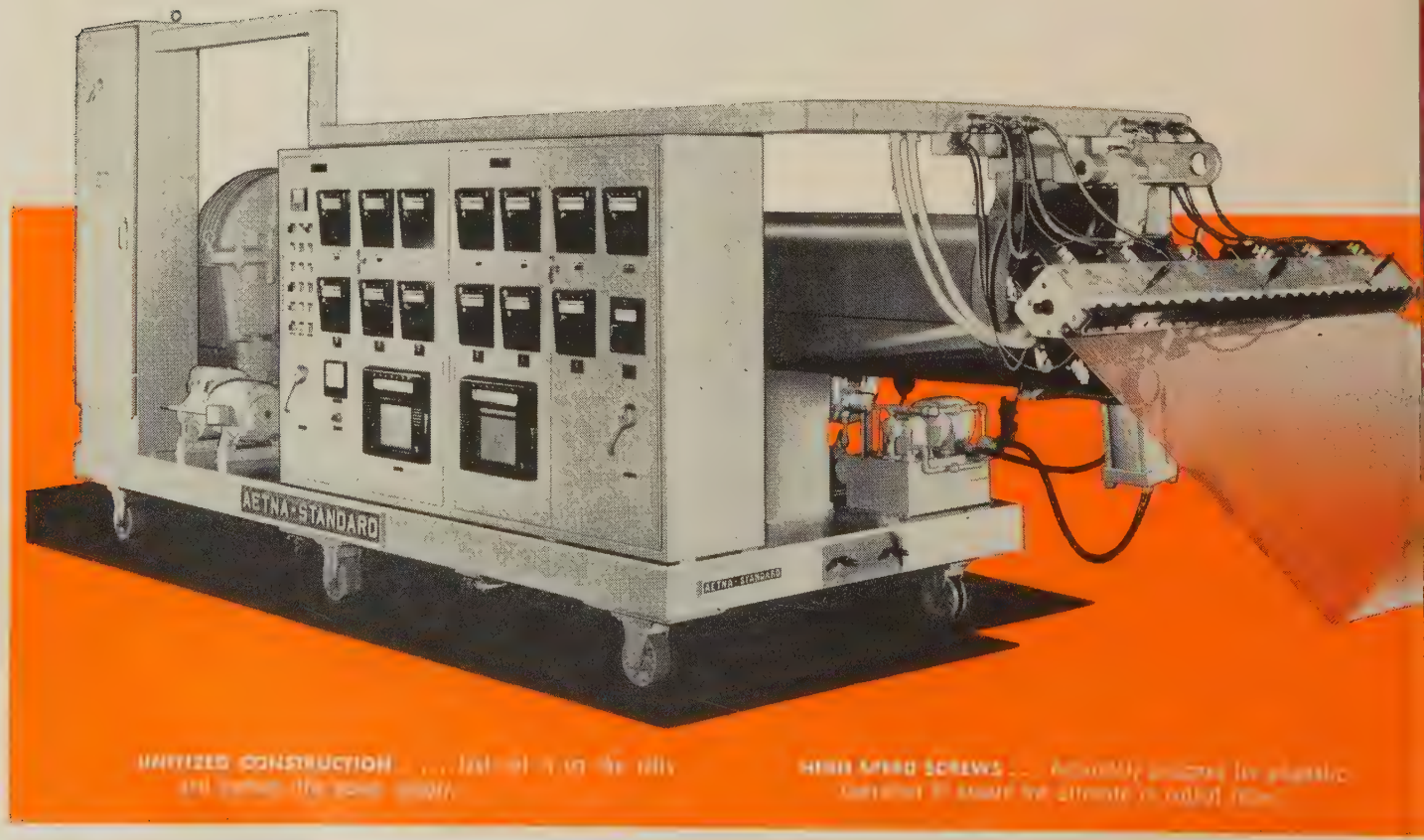

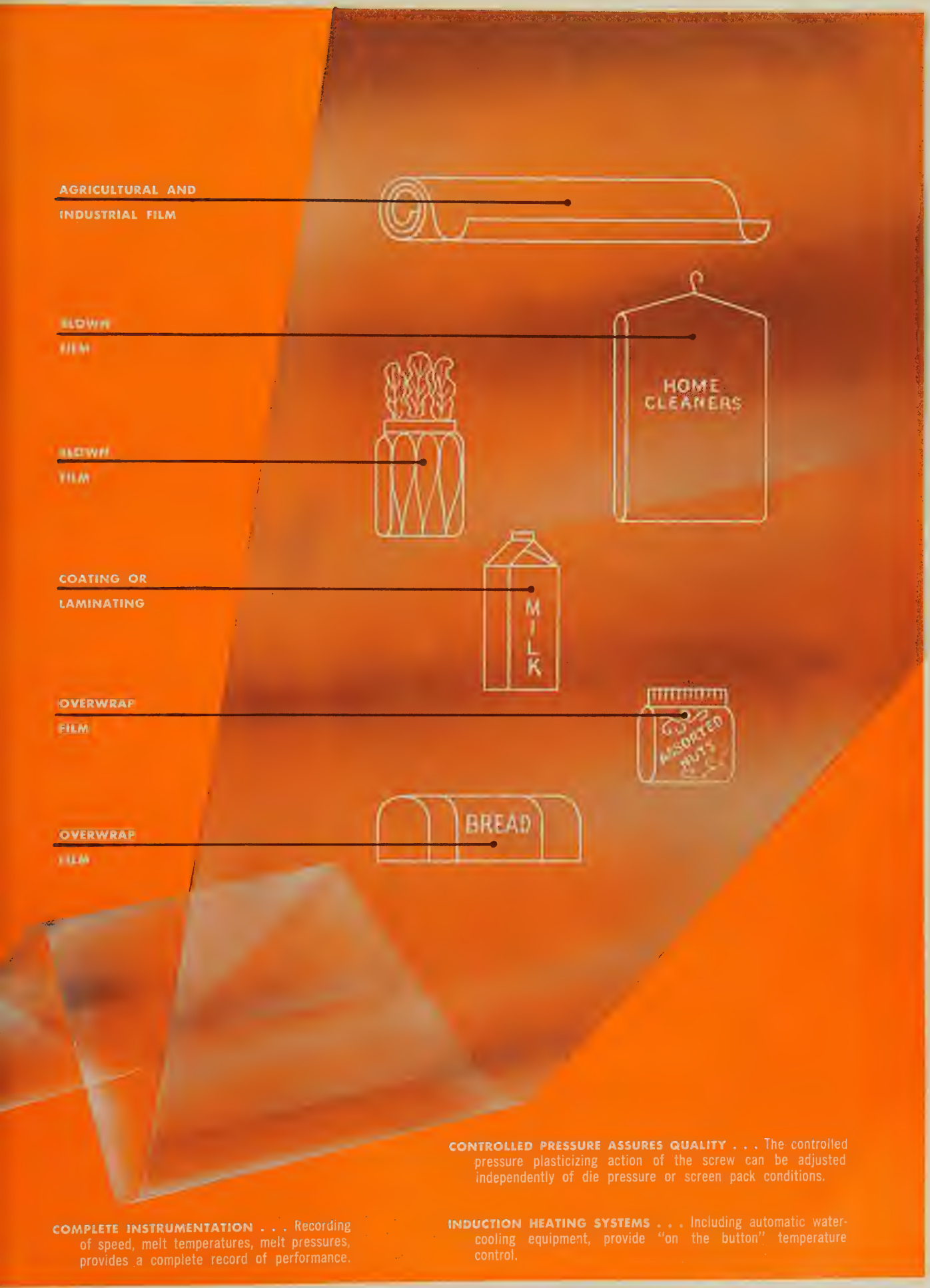

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tion to take advantage of the advice and assistance of other staff heads and the operating supervisors with whom he must work. It makes it possible for him to be completely attuned to the plant situation and its production or personnel problems, so that his work will be set in a practical reference and so that he will be aware of opportunities for improvement or innovation. It is necessary, however, that there be a clear-cut understanding of where his responsibilities end. Most of what he does is put into practice by others, especially the line organization. The engineer must be responsible for the accuracy and integrity of his work, but at the same time, he should consult with plant supervision so that there is an adequate interchange of information and viewpoints. Once the project is completed and accepted, the responsibility for results must be assumed by the line supervisor, with the industrial engineer serving as consultant if needed.

In both incentive and methods work, it is essential that the supervisor in charge be thoroughly convinced that the plan will work and know how to make it succeed. The foreman or superintendent who says, "This is the industrial engineer's plan, not mine," is not a fully responsible manager and will not get results. It is the job of the plant manager, however, to make sure that the proper working relationships are established and understood. It is also his job to see that the proper parties are brought into any project at the start. We all waste a lot of time by failing to do this. Likewise, we spend far too much time trying to solve problems and not enough in defining what we are trying to solve. As a rule, the problem that is clearly defined is half-solved.

In discussing the areas where industrial engineers can make a significant contribution, I will make no attempt to cover the whole field, but rather will concentrate on what I consider the more important, hopefully in such a manner that additional opportunities will come to your mind. Cost planning and reporting is one of the most important. In my judgment, American industry in general does not know enough about costs and how to manage them. A good cost system should naturally give us accurate information on all significant items that make up the cost of a product or service. Furthermore, it should tell us what the cost of that product should have been for the conditions under which it was manufactured. Beyond this, it should give us the basic information needed to plan cost improvement. It should tell us how to price the product properly; it should enable us to evaluate precisely the benefits to be expected from replacing old facilities, expanding the capacity of existing facilities, or building new. It should be the basis for our long-range planning and should tell us what our financial position will be at varying levels of production. It should be a tool for operating management, as well as for financial management.

These requirements are fulfilled by a comprehensive standard cost system, the foundation of which must be the basic quantities of labor, materials, and equipment time that are needed to produce any specified thing, whether it be a raw material, a finished product, or a service. Expressed in physical quantities, the elements of cost remain constant, regardless of what may happen to wage rates or prices. Dollar values can be assigned readily by application of the proper factors. A suc-

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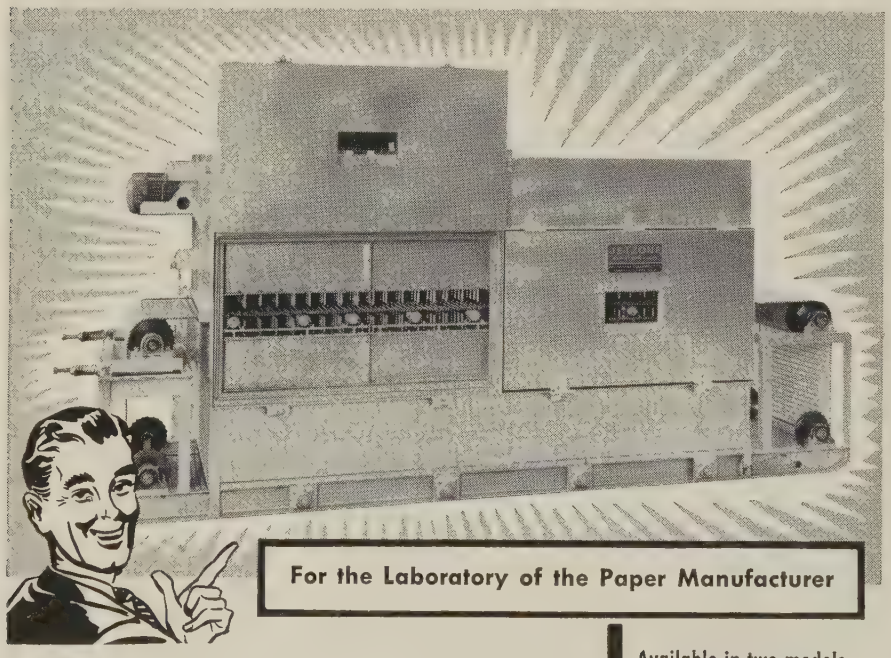

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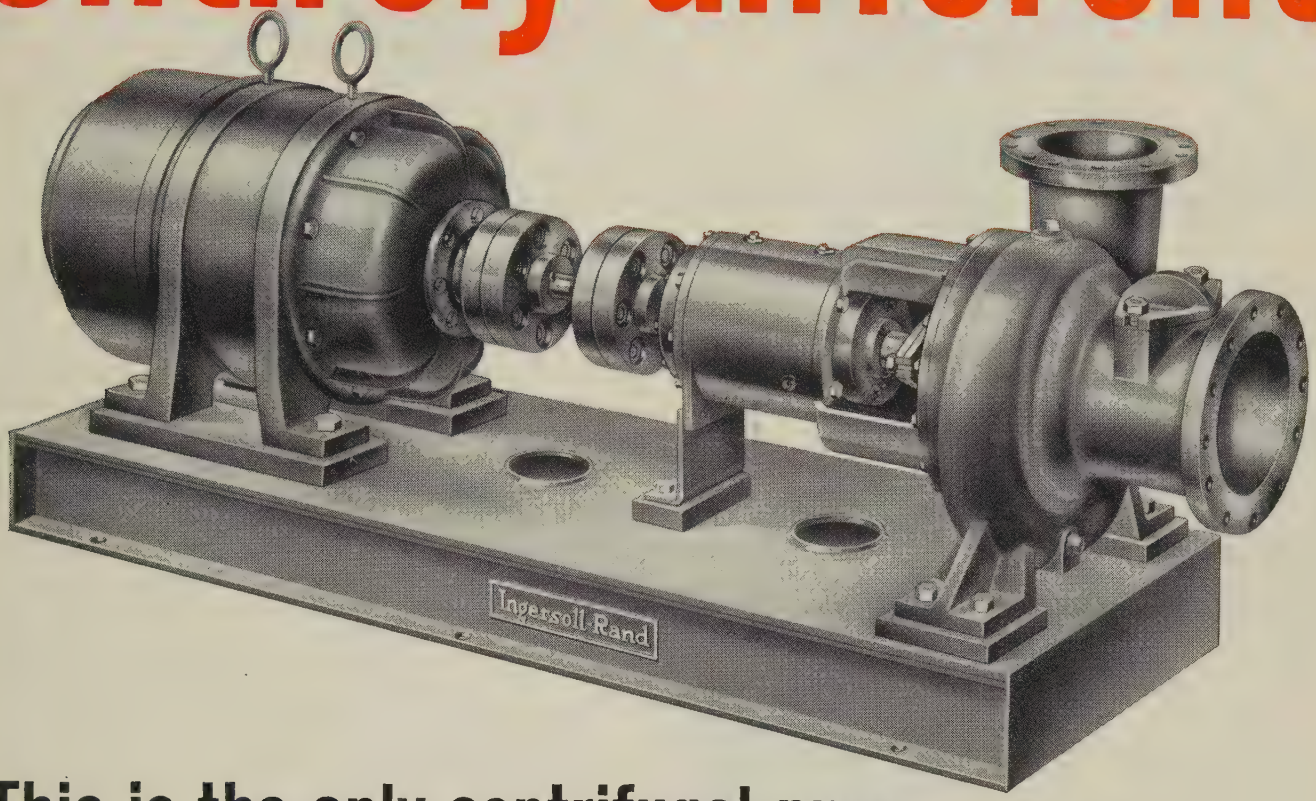

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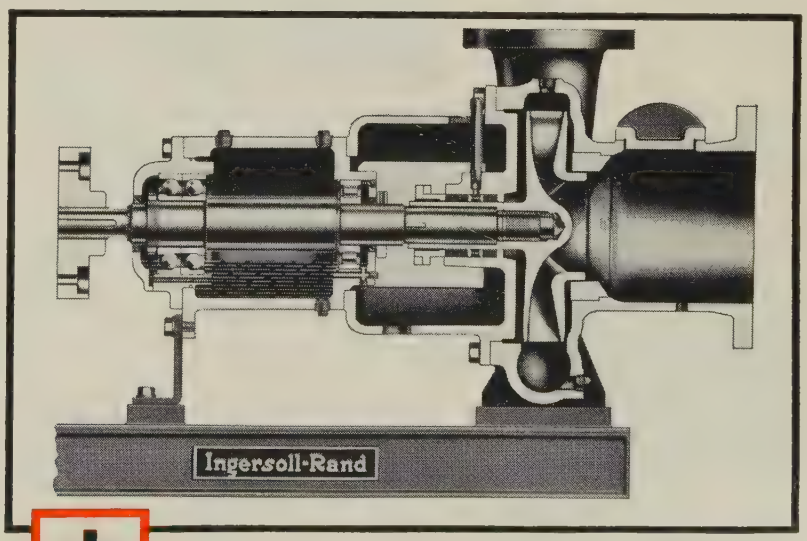

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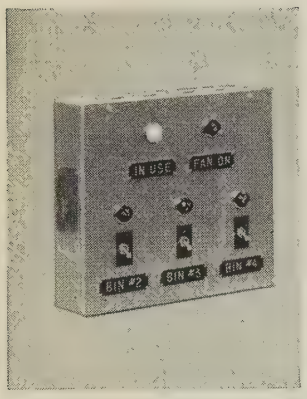

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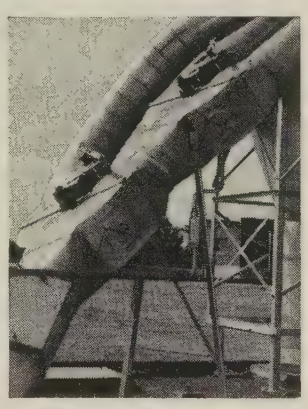

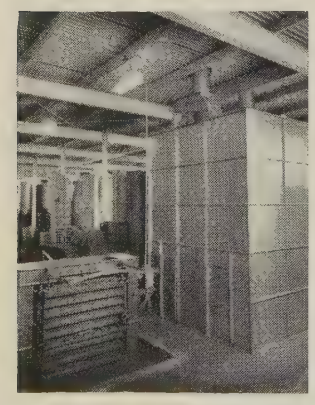

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cessful standard cost system must be a joint venture of operating and accounting, and industrial engineering is best qualified to represent the operating function. In the application and administration of basic standards for a standard cost system, the industrial engineer is presented with a limitless opportunity for service to management.

He can give the department foreman a detailed schedule of the equipment hours needed for the next week's production. He can tell him how many hours of labor he should schedule, by position, both direct and indirect. He can tell him how many dollars worth of tools, supplies, and materials he should consume for the products he is scheduled to make. He can tell him the standard production rate for each product. As against these forecasts, the accountant can tell him currently how he is performing. If he has cost problems, the industrial engineer should be able to spot the causes if they are not obvious. I would also expect the industrial engineer to be the instrument through which the standards were maintained, in cooperation with the operating supervision, and I would also expect that in performing all of these functions he would use the most modern and efficient office techniques, including electronic data processing and computers where justified. He should further make himself a sort of gadfly, personable but persistent, to the superintendent, showing him where improvement could be made and then helping him make it. He should feel just as responsible for the success of the plant as the plant manager himself. Standard costs are truly an opportunity for the industrial engineer.

Facility planning is an activity where proper industrial engineering participation can increase the benefits of capital expenditures. In the initial survey stage, basic standards information can indicate where the return will be the greatest by setting up alternate programs and evaluating each. This is done best by constructing what might be called a model of the situation that would exist after the installation of the facility and comparing this with the prior condition, using the estimated standards for the new facility. If this is done for the possible alternative plans, management is assisted materially in determining which course to take.

In the process of determining the standards for the projected facility, industrial engineering techniques should be followed in analyzing each step of the process and arriving at the proper crew size, the maintenance requirements and how they will be fulfilled, material flow to and from the producing units, and other questions that must be faced when the equipment goes into operation. The number of control stations that are needed, whether two or three, can be combined into one to eliminate operators, the degree of automation that can economically be worked into the process, are matters that should be settled before the facility is designed, and even before a final decision is made on the expenditure if possible. Some companies have employed scale models to good advantage to introduce a note of realism into such studies. Here again, thorough analysis and consideration of the problem can save time and money later. Although this approach to facility planning may appear to be laborious and unduly detailed, I am convinced that if it is made a regular procedure to be followed on all expenditures

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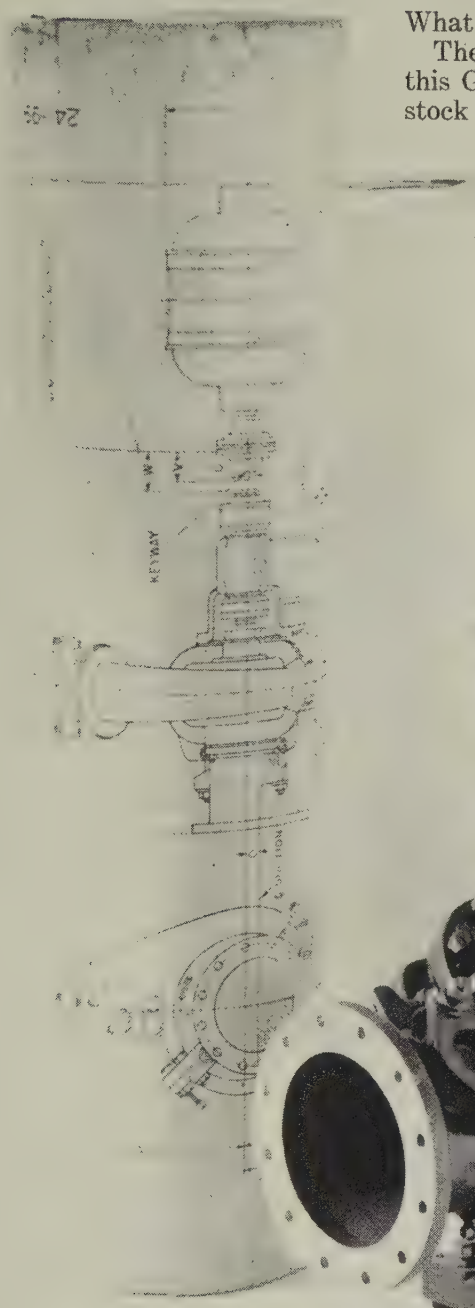
The pump that refuses to choke on paper stock!



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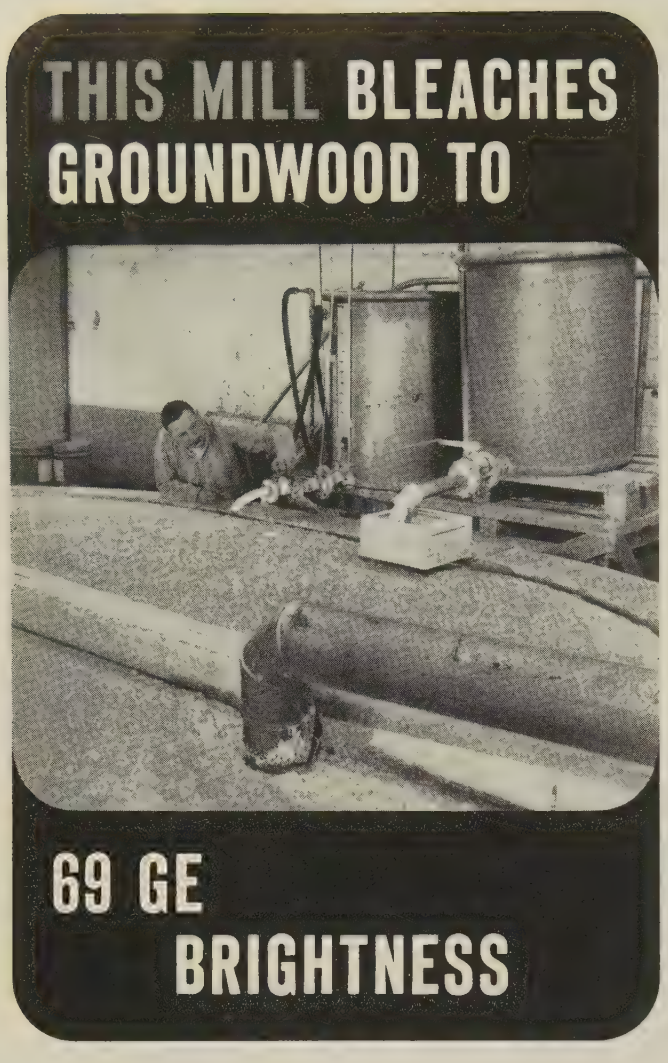

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of any significance, it can be done expeditiously and without seriously deferring a decision.

In this same connection, I would like to speak of a concept of job analysis and classification which I think has substantial merit. Traditionally, we have worked in the direction of simplifying jobs, making them easier, and by the introduction of machines, extracting much of the skill that used to be required. There are exceptions, of course, especially in maintenance and craft work, but we have been successful on occasion to the extent of establishing jobs that consisted only of placing a bolt in a hole for eight hours a day.

Consider, on the other hand, that we have now reached the point where a mechanical operation can generally be performed better by a machine than a man and, at present wage rates, more economically. If we will think about man's peculiar attributes, we will conclude that his power to think and his versatility are the qualities which a machine can never duplicate. Why not design jobs to take advantage of this ability, rather than downgrade the job to the point where a child could do it? Why not build as much content into a job as a man with normal intelligence and proper training can reasonably handle? The results can be most satisfying. In the first place, we have constructed a real job—one that requires skill and will be a challenge instead of a bore. The rate for the job will be higher and thus will command better men, and yet the company should benefit because there will be fewer jobs.

It should be realized that in following this concept of job development there may be resistance on the part of the operating supervision because more training is required and because there will not be the cushion in the work force that has formerly been there. On the other hand, we read about the benefits of automation and modern science and how they will substitute machine power for man power and raise our standard of living. Certainly they will, but only if we plan it that way. The approach to facility planning and job analysis that I have described is one sure method of capitalizing on our scientific and industrial know-how, and industrial engineers should be leading the field in this work.

Methods work, in a sense, is really the core of industrial engineering. How we work and why we do certain things are questions that concern us regardless of whether we are developing a cost system or studying an operation for incentive coverage. The usual concept of methods study consists of selecting an operation, breaking it down into its individual components, analyzing these for elimination or improvement, reconstructing the better method, and putting it into effect. This is otherwise known as the scientific method of problem solving or, in logic, inductive reasoning. It has served us well, but there is a growing awareness that this approach tends to overlook large potential by concentrating on the bits and pieces. In logic, the reverse of inductive reasoning is called the deductive method, by which general principles are first stated, and from these, certain conclusions are drawn and then confirmed. Some of our greatest scientific advances were the result of deductive reasoning. Translating this principle into our own field, we are finding that if we observe an operation in its

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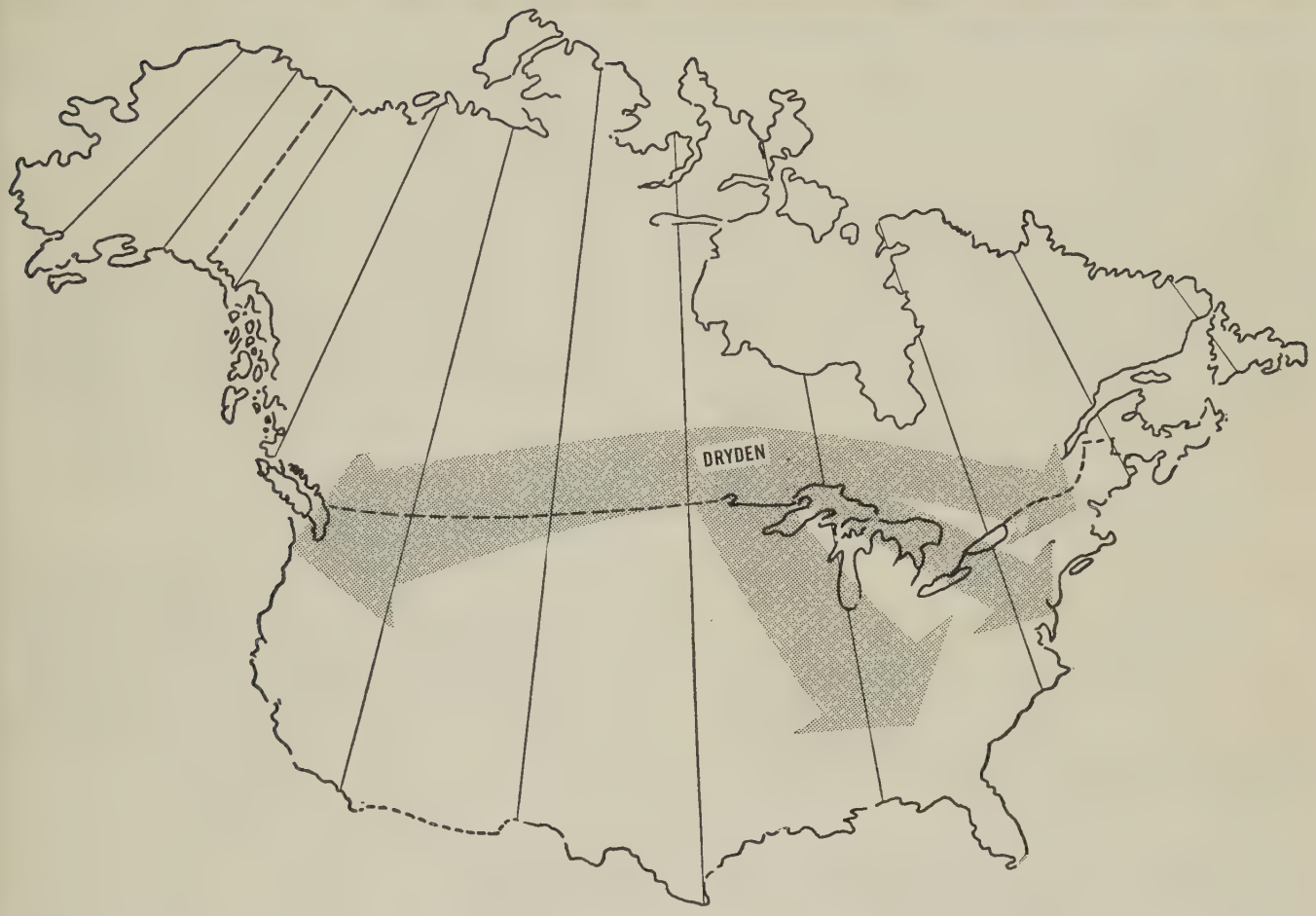

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entirety, as a complete system, it is possible to discern major faults or inconsistencies that were not apparent when we were examining the elements. If solved, these could lead to substantial gains.

New tools and techniques have served to give impetus to the practical application of this principle. Electronic computers have made possible the simulation of a complete operation in mathematical terms, and because of their rapidity, a synthetic operation can be run through a sequence of cycles under variable conditions in a very short period. New methods of scheduling, manning, and transporting can be tried out on a theoretical test-run without ever involving the operation itself. Other techniques involve such mathematical applications as the theory of games, probability, and linear programming. Other approaches are simply a revival of the practice of setting up a complete but concise process flow chart which can be studied by operators, industrial engineers, or other staff and accounting services. The technology employed can be as sophisticated as you want to make it; the important consideration is to look at the whole problem, not just the parts. This is not to say that the traditional methods approach is wrong, because we know it has worked. If I were running a plant, I would have my industrial engineers doing both. A certain period of training may be necessary to let a man acquire some knowledge of the new techniques and probably to brush up on his math. However, any competent engineer can learn these skills in a reasonable time, and the mechanics of programming are not so abstruse that only eggheads can qualify. Part of the problem lies in the fact that the layman is so completely overwhelmed by the speed of the new machines that he considers them beyond the comprehension of any one but a Ph.D., and this is not so.

The result of this misconception has too often been that special bureaus have been organized, staffed with mathematicians, to carry out operations research and systems work. These men have to learn as much about the business as time will permit and then start cranking out answers. It would appear much more reasonable to select a few competent industrial engineers who know the business, send them to any of the schools that are available to teach the new methods, and in a short time have seasoned, knowledgable men to form the nucleus of an operations research group within the industrial engineering staff. By so doing, we also avoid setting up another staff department with a full complement of clerks, stenographers, and equipment. But the main reason why industrial engineers should carry out operations research is that, in my opinion, they will do a better job.

As to working relationships, I would use the team approach on more problems. Rather than assigning industrial engineers exclusively to a study, I would use them as part of a small group, consisting of qualified people from the several functions that were involved. Whether the industrial engineer were chairman or not would depend on the nature of the study, but his participation should be assured. Projects bearing on operations, facilities, quality, scheduling, maintenance, or clerical work should all present opportunities to a competent industrial engineer, and I would expect him to make a substantial contribution. Other functions which are traditionally assigned to industrial engineers, such as work measurement and incentives, cost reduction, and basic standards and budgetary control, can all be done more effectively if the engineering effort is properly integrated into the whole management program. Problems of communications and responsibility tend to disappear under such an arrangement, and recommendations for action are not only understood by all concerned, but are usually accepted when presented. This is what I mean when I say that management must make sure that the proper environment and organizational arrangements are provided if we are to capitalize on the ability of our industrial engineers.

If you will permit a suggestion, I believe it is ultimately worth while to survey as objectively as you can the position of industrial engineering in your company: its status in the organization; the aspect that it presents to those outside the department; its participation in the company's management of the business; the contribution it should be making to the performance of the enterprise. If what you see falls short of what a good standard would represent, I would set down on paper the steps to be taken to reach that standard, and not rest until each step was accomplished. You already have certain suggestions on how this may be done.

In this discussion this morning, I hope I have accomplished several things. Initially, I described an attitude of apathy and lethargy, which, I fear, is more pervasive in the younger generation than we realize. The oncoming battle for world markets is too menacing for us to permit such an attitude to prevail. The means for maintaining our present competitive position and improving it has been with us all along, but for various reasons we have not made full use of it. Scientific management, employed with all the skill and diplomacy at our command, in a sustained and permanent course of improvement, can assure our survival and guarantee that succeeding generations will have the same opportunities we have enjoyed. The practice of industrial engineering precepts and skills is the basis of scientific management. If we subscribe to the principle of constant improvement, we will employ all of this knowledge with all the determination possible. The question is: "Do we really mean it?" Will we really do the things that must be done to keep us out in front? I sincerely hope so, and if I have raised your sights and added to your determination to "shoot the moon," I will feel that this has been a most rewarding experience.

Presented at the 14th Engineering Conference of the Technical Association of the Pulp and Paper Industry, Pittsburgh, Pa., Oct. 14, 1959.

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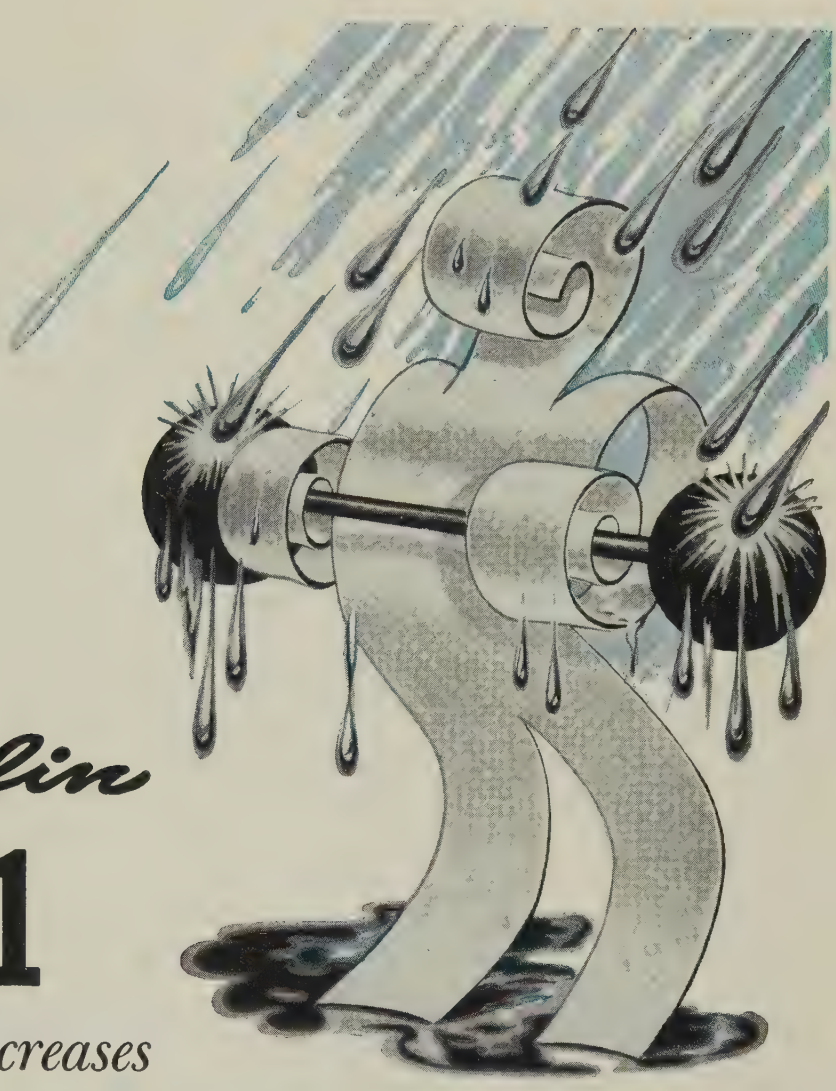

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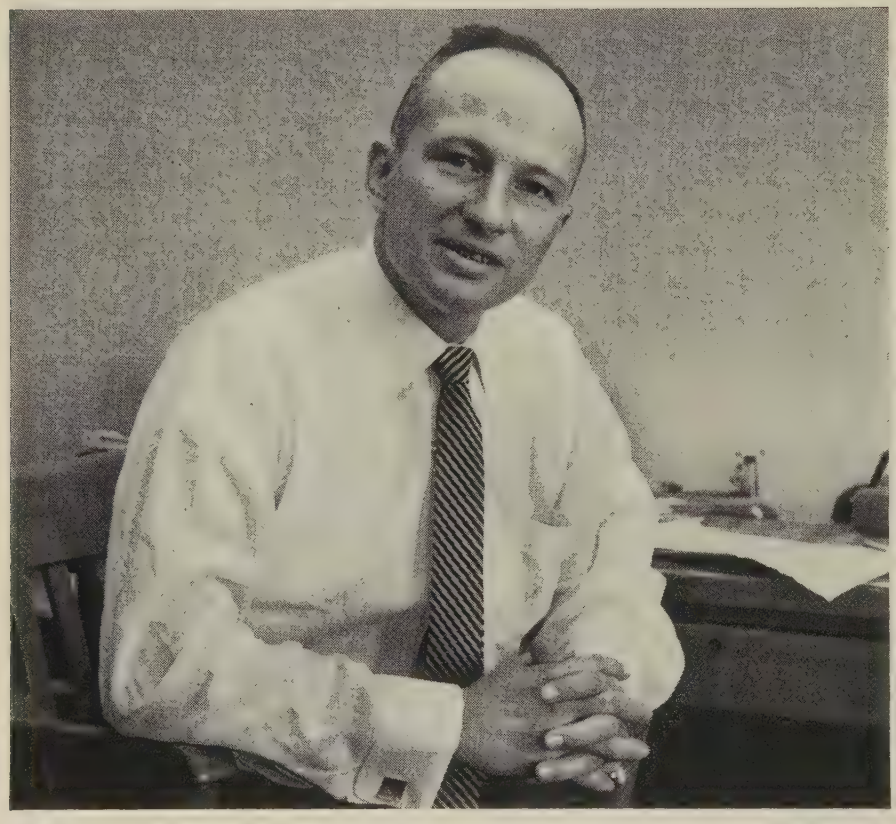
"Combination bleaching of mechanical pulp —following peroxide with a hydrosulfite— can give you brightness gains of 15 to 20 points"

Robert Barton, a technical representative for Virginia Smelting Company, discusses the advantages of 2-stage bleaching from the standpoint of costs and results.



Robert Barton, a "Virginia" technical representative

Q Why does 2-stage bleaching give more brightness gains?

A Because the action of peroxide and hydrosulfite on pulp is not the same. Each gains its effect in a different way, and while there is some overlap in their action, there is a very worth-while cumulative effect. In other words, where you can reasonably expect a brightness gain up to 12 points using either bleach alone, the two bleaches used consecutively jump the results to anywhere from 15 to 20 points.

Q What are the advantages of 2-stage bleaching?

A Lower costs and better results—especially if the mill is now using some agent other than hydrosulfite for its single-stage bleaching. The big financial advantage in switching to a combination bleach goes to the pulp mill now using a single stage of peroxide.

Q How does the 2-stage bleach cut costs?

A The principle is to use as little of the more expensive peroxide as possible. The first stage is a bleach with peroxide. Follow this with a hydrosulfite bleach and you have cut the heart out of bleaching costs, at the same time stepping up the quality of the final product. Higher brightness and lower costs are the main reasons why 2-stage bleaching is becoming increasingly popular.

Q Can this process be applied to any kind of pulp with the same results?

A No, the response varies slightly with the wood from which the pulp is made. Good results have been obtained with spruce, poplar and pine groundwood pulps and with a large number of semimechanical pulps made from many species of caustic or sulfite pretreated hardwoods. Mixtures of chemical and mechanical pulps also respond favorably.

Q How can pulp manufacturers find out whether or not the 2-stage bleach will be advantageous to them?

A Simply by calling on the services of "Virginia." We can bring our lab equipment right into a mill, make tests, and demonstrate the possibilities of 2-stage bleaching under practical operating conditions. We will lend the mill any necessary equipment, find a spot in the system where the hydrosulfite stage can be inserted, and help run a mill trial. If the 2-stage process proves desirable, we will stay on the job and help iron out any technical problems that might arise. Under circumstances like these a pulpmaker can easily see where costs are being cut—and examine the improved final product with his own eyes. This is the kind of technical service on which "Virginia" has built its reputation.

• • •

For more information on 2-stage bleaching with "Virginia" zinc or sodium hydrosulfite, write us giving any technical data that may help us evaluate your problem. We will forward technical literature and run laboratory tests provided you furnish us fresh pulp samples. Or, if you say so, we will have a "Virginia" man call and talk over your requirements with you.

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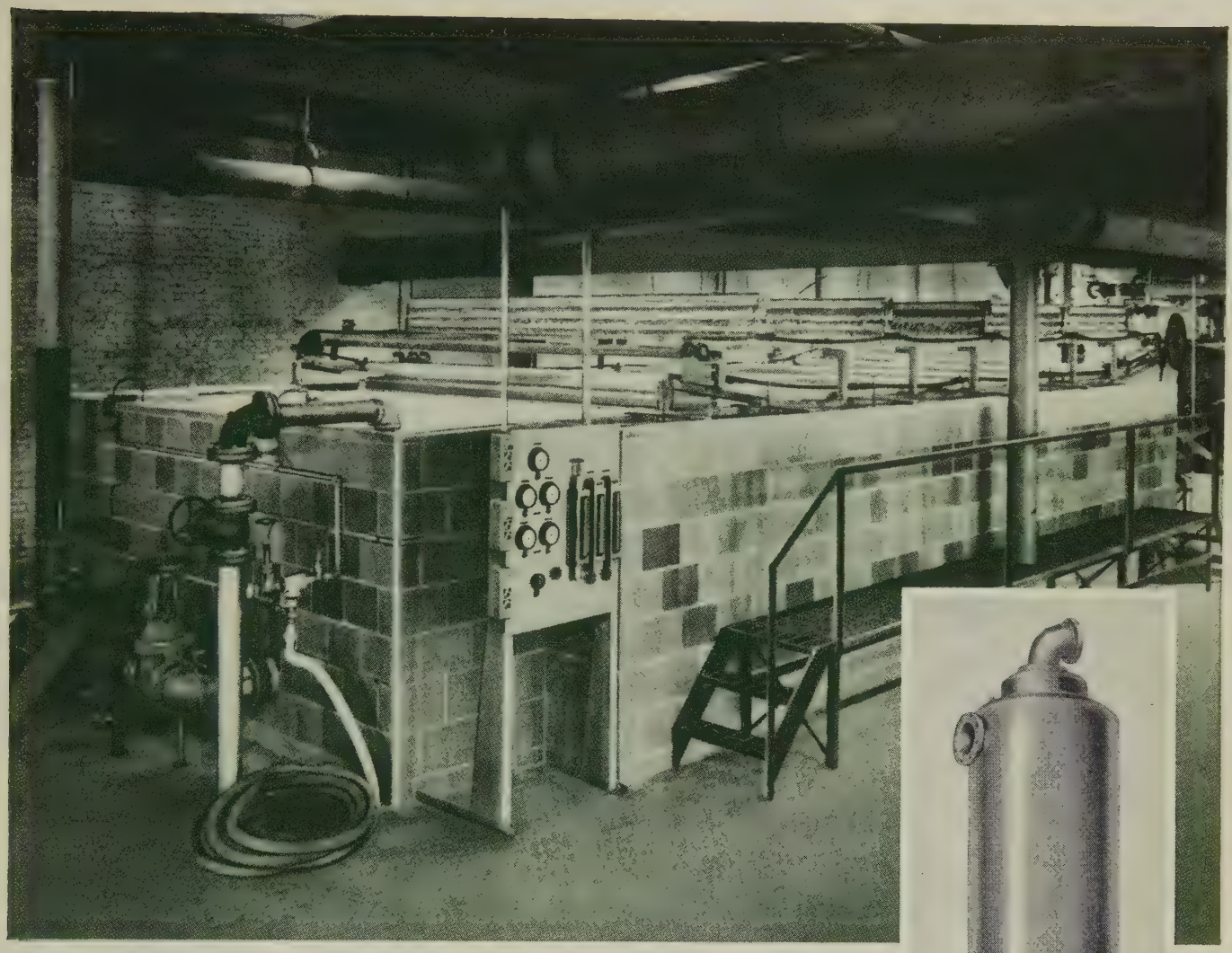
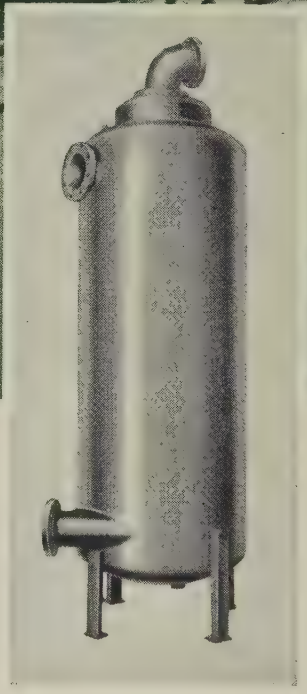
The Sveen-Pedersen Saveall with "Aqua-Air-Spray"*





"Aqua-Air-Spray"* Aeration Tank is automatic, simple, maintenance free. Drives more air into solution under pressure. Air-saturated white water is then released and distributed through either horizontal or vertical type Double Disk Inlet Valve*.

Recovers fiber and filler more efficiently than ever

Long recognized as the world's finest flotation saveall unit, Sveen-Pedersen now increases its lead even further. Through a field-proven, revolutionary "Aqua-Air-Spray"* system, more than twice as much air as previously possible is *dissolved* into the white water. Millions of tiny air bubbles are made available to float the fiber and filler out of the solution.

As a result, S-P Saveall — now made by Jones — offers these important advantages: Greater fiber and filler recovery — faster and in higher concentration • Better water clarification • Reduces — or even eliminates — flocculent chemical dosage • Requires up to 20% less pump horsepower • Minimizes maintenance.

For full details on the reclaiming of expensive fibers and fillers, and effective solutions to stream pollution problems, write to E. D. Jones Corporation, Pittsfield, Mass. Ask for bulletin F-10.

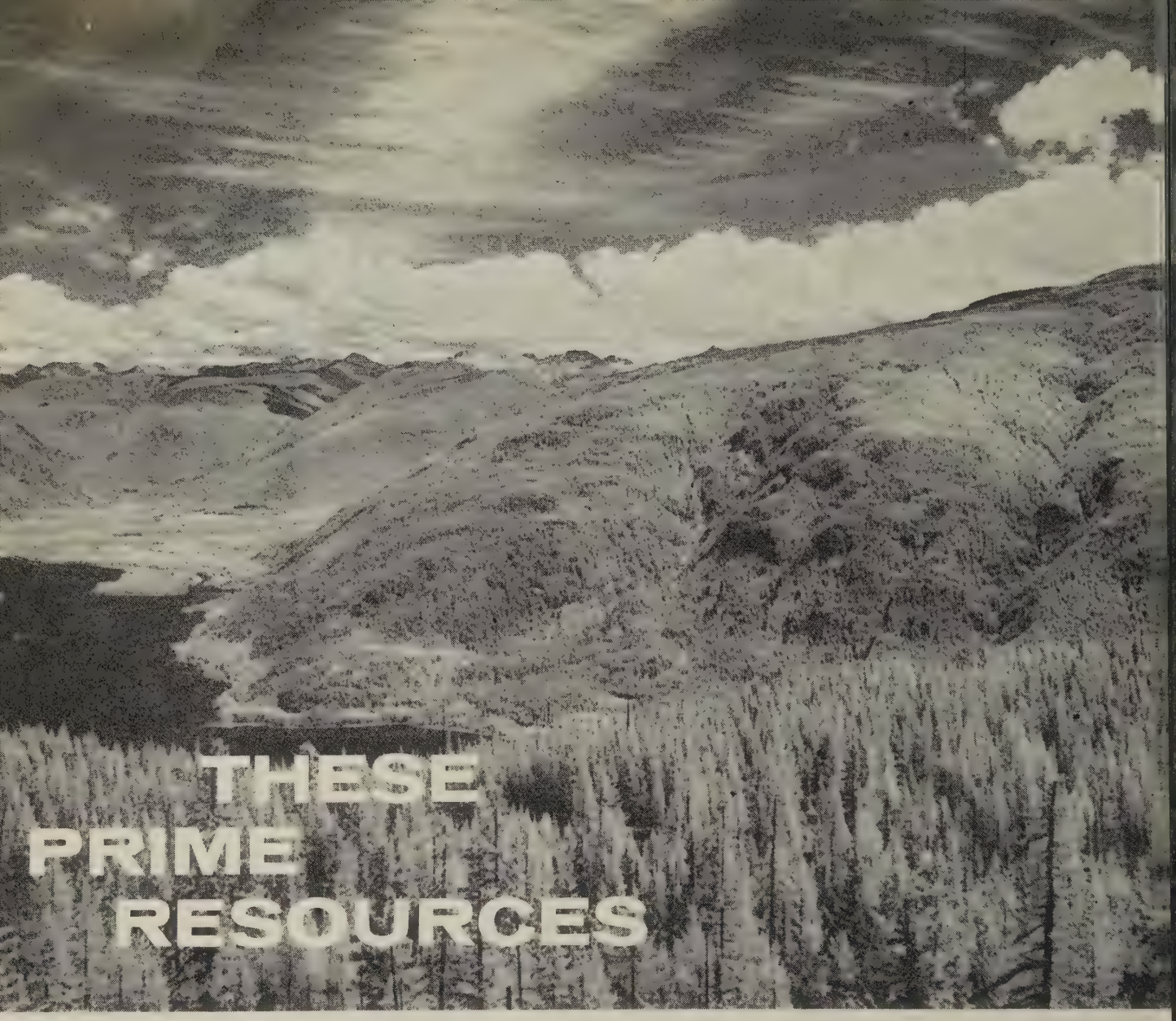
*Patented

Canadian Associates:
The Alexander Fleck Ltd.
75 Spencer Street, Ottawa

E. D. JONES CORP. MEMBER BELOIT GROUP PITTSFIELD, MASS.

Jones

PULP MILL EQUIPMENT AND STOCK PREPARATION MACHINERY



B.C. Forest Service i

PROMISE HIGH QUALITY BLEACHED PAPER PULP IN 1961

Early in 1961, a new high quality market pulp mill will go on stream near Castlegar, British Columbia, at the foot of the Arrow Lakes region of the Columbia River. Celgar Limited will utilize almost 900,000 acres of prime northern-type forest lands held under a Tree Farm Licence in perpetuity.

All the resources necessary for efficient mill operation are available — wood to meet any future demand, plentiful water from the clear Columbia, power and gas, transportation from the mill site to markets, and trained people from established industrial communities in the area.

Celgar Kraft will combine many of the best qualities of Northern and Western pulps to produce a product with an exceptional balance of properties. The long, tough fibres from high-density softwoods develop high bursting strengths coupled with outstanding tear resistance over a wide range of freeness, and in a variety of stock preparation equipment.

COLUMBIA PULP SALES LIMITED has been formed to distribute Celgar Kraft pulps and Columbia Cellulose sulphite pulps. Offices are located at:
1030 West Georgia St., Vancouver 5, B.C.
1600 Dorchester St. West, Montreal 25, P.Q.

V4247-1

Celgar Kraft

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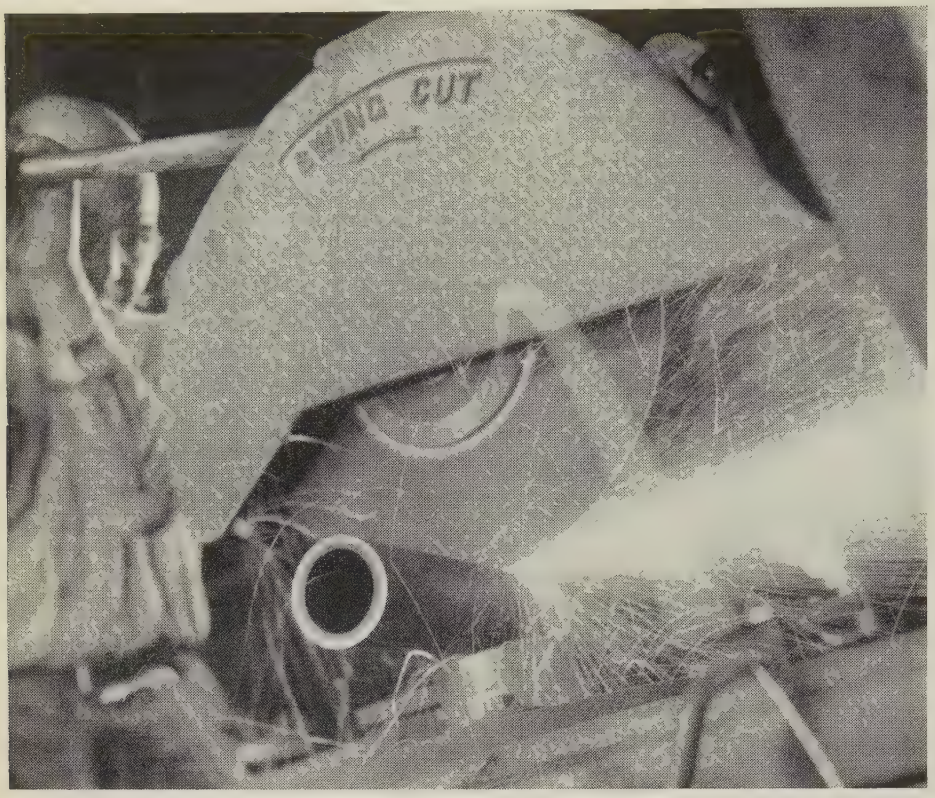
FLUIDICS* AT WORK



Now . . . GLASTEEL pipe that you can field-cut

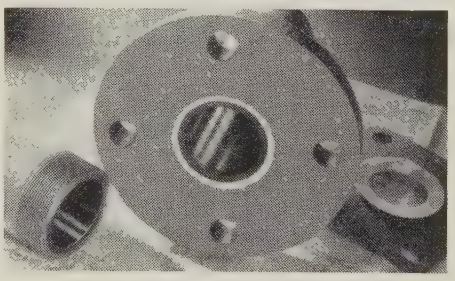
That's new Pfaudler F-C Glasteel pipe* you see being cut with a standard, dry abrasive cutoff wheel.

The F-C stands for "field cut." The pipe itself is steel on the outside for strength, borosilicate glass on the inside for corrosion resistance. Once you've cut the length you want, you thread and then fire-polish with a small, portable furnace. (Furnace available from Pfaudler at a modest cost that you will completely recover through savings in a few installations.) You finish the pipe end with a belt sander to make sure that the gasket seat is flat and the flange connection seal-tight.

Glass lining for this new pipe is ⅛ inch thick, so you can expect substantially longer service life even with corrosive and/or abrasive fluids. Rated at 150 psi and available in 1½, 2 and 3 inch diameters, F-C pipe can be used with all acids (except HF) to 350° F. and with all mild alkalies at moderate temperatures.

Moreover, since glass is inert, you will also find this pipe useful for those products which must be kept free from contamination. And note, too, that because glass is smooth, there's little chance for build-up with sticky materials.

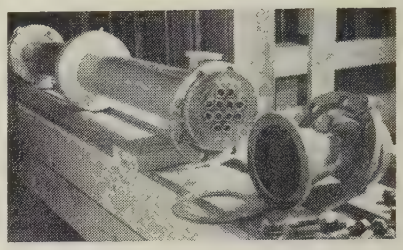
Aside from the fire-polishing furnace, you will find the tools needed for handling F-C Glasteel pipe in most plant maintenance shops. There is no need to engineer a piping layout to the last ⅛ inch. Installation and modification are easy, and very little maintenance is required.



As of now, you can get limited quantities from stock in lengths through 10 feet. For Bulletin No. 989 or for answers to specific questions on availability and delivery, please write to our Pfaudler Division, Dept. T-20, Rochester 3, N. Y.

*Patent applied for

Why and how to get a combination heat exchanger



Suppose you want to concentrate sulphuric or nitric acid on the tube side, using high pressure steam on the shell side. What kind of heat exchanger would you select?

Faced with this problem, our answer was a *combination*—bonnets of Glasteel, tubes and tube sheet of tantalum, and a shell of carbon steel, as illustrated above.

CHOICE OF MATERIALS. This combining of materials of construction is something we are in a unique position to handle. For example, from Pfaudler you can get components made from stainless, GLASTEEL, nickel, Inconel, Monel, Hastelloy, and impervious graphite.

And now you can even get the special characteristics of components fabricated by us from titanium, tantalum, and zirconium.

OPTIMUM DESIGN. The intent of combining materials is to provide the optimum design in terms of heat transfer efficiency and corrosion resistance at the *lowest cost*.

Since our background and facilities cover this wide choice, you are sure that your needs are met with complete objectivity. Your product, your process, and your budget will point the way.

YOU'RE INVITED. What it ends up with is this invitation: Consult with us on your problem. We will then submit our recommendation on the right combination. Or get more background from our Bulletin No. 949.

BUYERS' GUIDE. Outlines our FLUIDICS program in terms of services and products for corrosion-eering, water treatment, storage, agitation, etc. Send for your free copy.

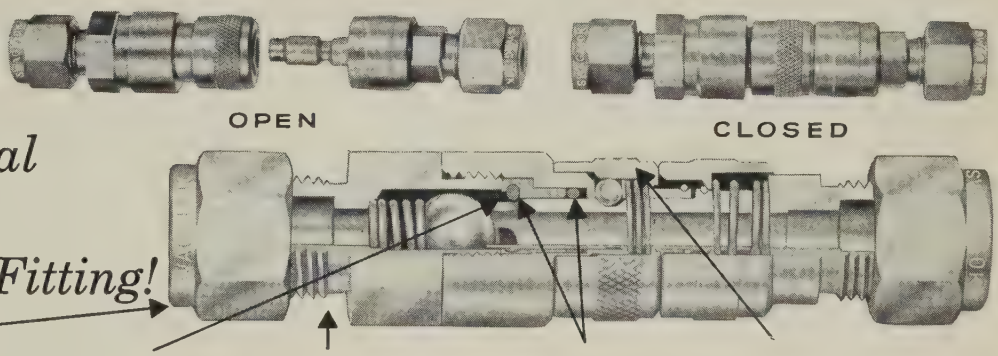
PFAUDLER PERMUTIT INC.

Specialists in FLUIDICS . . . the science of fluid processes

*FLUIDICS is the Pfaudler Permutit program that integrates knowledge, equipment and experience in solving problems involving fluids.

Swagelok Quick-Connect Fitting Installation in Boeing Airplane Company, Seattle, Wash., Test Facilities for Boeing 707 Jet Stratoliner.

Here's the secret of this fast, positive-seal Swagelok Quick-Connect Fitting!



1. Swagelok Quick-Connects with single end or double end shut off for tube to pipe, tube to tube, bulkhead tube to tube applications are available in brass and stainless steel in sizes for ¼" and ⅜" O. D. tubing.

2. Flow resumed instantly and vacuum tight seal assured when connection is made.

3. Light, compact, streamlined design. Occupies little space. For use with portable equipment, and bulkhead or panel applications.

4. Instant-acting seals completely prevent loss of pressure when fitting is disconnected.

5. No twisting, turning or wrench action necessary. Easy straight-line finger tip pull or push action for instant connecting or disconnecting.

In the Boeing Airplane Company photo shown above, the tubes are instrumentation pressure lines running from the large jet engines on test stands to the patch board, where the lines are coupled into measuring devices.

The Boeing Airplane Company adopted this positive Swagelok Quick-Connect Fitting to simplify test installations, and substantially cut down test set-up time. Both ends of the many pressure lines are Swagelok-equipped. Previously, engineers used a screw-type fitting which required a wrench and valuable time-consuming operations to tighten and remove.

Swagelok engineers are equipped with experience, ability, and a wide range of tube fittings designed to meet your individual problems. Quick delivery of Swagelok tube fittings from local distributor stocks.

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The Dollars and Sense of Capital Equipment Justification

WILLIAM H. BRICKNER

Among the many functions performed by management today, one of the most important is the proper allocation of the firm's capital to new projects. Since the situation in most companies is one of there being more requests for capital expenditures than there is capital available, it is important that this scarce commodity be properly allocated so as to provide the maximum results in achieving the firm's objectives in *future* years. I stress the future, since the full effect of capital expenditures is not usually felt until two or more years after the money has been appropriated. In addition, most such expenditures are irreversible, and the equipment or process, once installed, will continue to affect the company's profits for many years to come.

In view of the importance of having an effective method of choosing the right capital expenditures, this paper will endeavor to cover the following three phases of this problem:

Part I—The rationale of a "return on investment" approach to equipment justification, with emphasis on the discounted cash flow method of computing return.

Part II—A means of evaluating the element of risk inherent in any project.

Part III—Actual implementation of the return on investment procedure to the justification of an item of converting equipment.

PART I

Return on investment is a measure commonly used to determine what percentage of return, or interest, a company will derive from spending its capital on a given project. In many companies, the figure obtained is compared against similar figures for other projects:

1. As a means of ranking capital expenditure requests from the various plants or divisions to determine which projects are most desirable.
2. Against the minimum desired return rate for new projects. (Projects below this minimum level would normally be discarded.)

In view of the above, it is extremely important that the system for computing rate of return be as valid and reliable as possible so that the apportioning of capital funds will be done on an equitable and consistent basis.

Before discussing one or two of the procedures commonly used in industry today, it should be noted that a return on investment system consists of a number of parts, including:

1. Forecasts of the anticipated volumes, expenditures, capital, etc., over the estimated life of the project.
2. Development of proper cost rates to determine projected savings or profits.
3. Evaluation of the intangible items, such as the probability of success, in the proposed project.
4. A procedure, or a technique, for combining the above elements so that the answer will be as accurate a means as possible of indicating the return on the investment.

(It should be noted that Part I of this paper relates only to Item 4, the procedure, and not to the philosophy, techniques, etc., used in developing Items 1, 2 and 3. These points will be discussed in Parts I and III of this paper.) Since these first three items are frequently very subjective in nature, it becomes all the more important that the *technique* used in combining them to give the final answer be reliable, so that the overall "return on investment" system provides as accurate an answer as possible.

Criteria for a Reliable Procedure

Since there are a number of procedures that could be used in computing the "return" on a given project, it is important that the criteria of a good procedure be established. These criteria might be listed as:

(a) The percentage return must be a true interest rate and have the same significance as rates used in common financial usage.
(b) Irregular rates of savings or profits in future years can be easily handled.
(c) Additional capital expenditures spaced throughout the life of the project can be properly evaluated.
(d) The percentage return figures are consistent, regardless of the duration or magnitude of the project, so that the return from dissimilar projects can be ranked.

Common Procedures for Computing Return on Investment

A popular method for evaluating projects is to determine the net savings after depreciation and after income taxes, and to divide this figure by the capital investment required to give a per cent return figure.

The inadequacy of this method is that it assumes an even flow of annual savings, and cannot show the differences between projects that have large savings at the start and smaller savings at the end, and those projects that have low savings the first few years and then larger savings subsequently.

In order to attempt to correct for this deficiency in this procedure, the payoff period is also computed. This period is obtained by dividing the capital investment by the annual cash flow (after-tax profits and annual depreciation). The problem then becomes a matter of trying to assess the relative importance of payoff years versus return on investment for different projects. For example, which project is more desirable, one with a 7-yr. payoff and 19% return or one with an 8-yr. payoff and 22% return?

The Discounted Cash Flow Technique

In the criteria for a sound return on investment, procedure indicated that the percentage return should be consistent in meaning to that used in financial circles. For this reason, the theory of the "Discounted Cash

William H. Brickner, Product Planning Manager, The Mead Corp., New Products Division, Cincinnati, Ohio.

Bigger Sales...

- No decrease in tensile strength
- Increased cross-directional tensile strength
- No effect on colors
- Rewetting properties are unaffected

Better Production...

- Machine speeds maintained or increased
- Smoother running machines — less down time
- Will not yellow or develop odors on ageing
- Will not foam or froth in use

CELLOLUBE® Q-2

Quaternary Ammonium Paper Softener

Cellolube Q-2 softens napkins, tissue and towel stocks *without adverse effect on physical properties* — puts added "soft sell" in the finished product . . . without creating processing problems. And Cellolube Q-2 gives you wider latitude in pulp selection too! Sheets leave the doctor blade more uniformly, with a finer crepe. And machines actually run more smoothly with less down time. For a revelation in superior paper softening test Cellolube Q-2 now!

Economical Cellolube Q-2 treats tissue stock for as little as $1.33 per ton, and toweling for $3.30 per ton. Increased processing speeds may actually lower your over-all costs! Tanatex is prepared to demonstrate Cellolube Q-2 in your mill on a full scale trial. For details write, wire, phone:

TANATEX CHEMICAL CORPORATION

Belleville Turnpike, Kearny, New Jersey
WYman 8-0732

CHEMICALS
FOR DIFFICULT PROCESSING

Table I. Repayment of $10,000 in 5 Years at 5% Interest

End of year	Interest due (5% of money owed at start of year)	Total money owed before year-end payment	Year-end payment	Principal repaid	Money owed after year-end payment
0	...	...	...	...	$10,000.00
1	$500.00	$10,500.00	$2309.75	$1809.75	$ 8,190.25
2	$409.51	$ 8,599.76	$2309.75	$1900.24	$ 6,290.01
3	$314.50	$ 6,604.51	$2309.75	$1995.25	$ 4,294.76
4	$214.74	$ 4,509.50	$2309.75	$2095.01	$ 2,199.75
5	$109.99	$ 2,309.74	$2309.74	$2199.75	$ 0.00

Flow" technique will be developed through an analogy with a very common financial investment involving a return—the home mortgage.

When a bank lends money for a home mortgage, it sets up a repayment schedule of even payments that each year, both principal and interest are repaid. The size of the payments are such that each year the bank will get the same per cent of interest (or return) on the unpaid balance of the mortgage, and at the end of the mortgage period, the entire principal (or capital investment) will have been repaid. Table I shows a typical repayment schedule for a 5-yr., 5%, $10,000 mortgage, assuring annual repayments. The annual repayment of $2,309.75 completely repays the principal in 5 years and yields the lender a 5% return on the unpaid principal.

Table II. Present Worth Tables

	Present worth factors					
	4%		5%		6%	
Year	Single payment	Uniform payment series	Single payment	Uniform payment series	Single payment	Uniform payment series
1	0.9615	0.962	0.9524	0.952	0.9434	0.943
2	0.9246	1.886	0.9070	1.859	0.8900	1.833
3	0.8890	2.775	0.8638	2.723	0.8396	2.673
4	0.8548	3.630	0.8227	3.546	0.7921	3.465
5	0.8219	4.452	0.7835	4.329	0.7473	4.212
6	0.7903	5.242	0.7462	5.076	0.7050	4.917
7	0.7509	6.002	0.7107	5.786	0.6651	5.582
8	0.7307	6.733	0.6768	6.463	0.6274	6.210
9	0.7026	7.435	0.6446	7.108	0.5919	6.802
10	0.6756	8.111	0.6139	7.722	0.5584	7.360

Table III. Hypothetical Analysis for Comparing Two Different "Return on Investment" Procedures

Example 1—Even Annual Flow of Savings[a]

Year	Annual pretax savings before depreciation	After tax savings after depreciation	Annual depreciation	Annual cash flow	Present worth factor at 6%	Present worth at 6%
1	5,200	1,125	2,950	4,075	0.9434	3,844
2	5,200	1,125	2,950	4,075	0.8900	3,627
3	5,200	1,125	2,950	4,075	0.8396	3,421
4	5,200	1,125	2,950	4,075	0.7921	3,278
5	5,200	1,125	2,950	4,075	0.7473	3,045
6	5,200	1,125	2,950	4,075	0.7050	2,873
7	5,200	1,125	2,950	4,075	0.6651	2,710
8	5,200	1,125	2,950	4,075	0.6274	3,557
9	5,200	1,125	2,950	4,075	0.5919	2,412
10	5,200	1,125	2,950	4,075	0.5584	2,275
Total	52,000	11,250	29,500	40,750	7.3602	30,042

Example 2—Increasing Annual Flow of Savings[b]

Year	Annual pretax savings before depreciation	After tax savings after depreciation	Annual depreciation	Annual cash flow	Present worth factor at 4%	Present worth at 4%	Present worth factor at 6%	Present worth at 6%
1	500	1,225	2,950	1,725	0.9615	1,658	0.9434	1,627
2	1,500	725	2,950	2,225	0.9246	2,750	0.8900	1,980
3	3,000	25	2,950	2,975	0.8890	2,645	0.8396	2,498
4	5,000	1,025	2,950	3,975	0.8548	3,398	0.7921	3,149
5	7,000	2,025	2,950	4,975	0.8219	4,089	0.7473	3,718
6	7,000	2,025	2,950	4,975	0.7903	3,932	0.7050	3,507
7	7,000	2,025	2,950	4,975	0.7599	3,781	0.6651	3,309
8	7,000	2,025	2,950	4,975	0.7307	3,635	0.6274	3,121
9	7,000	2,025	2,950	4,975	0.7026	3,495	0.5919	2,945
10	7,000	2,025	2,950	4,975	0.6756	3,361	0.5584	2,778
Total	52,000	11,250	29,500	38,880	8.1109	32,744	7.3602	28,629

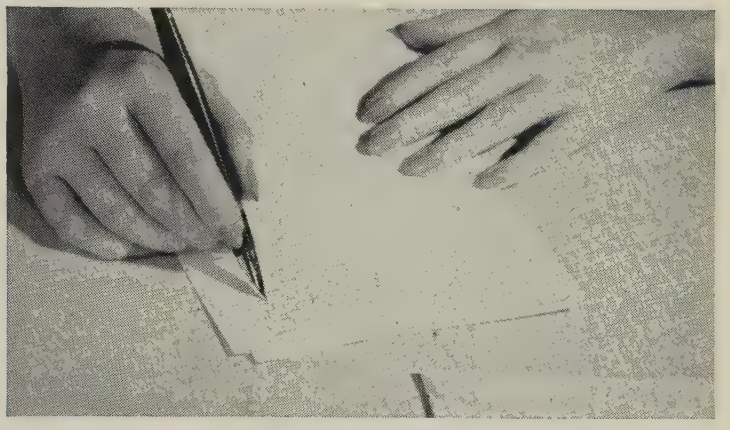
Example 3—Decreasing Annual Flow of Savings[c]

Year	Annual pretax savings before depreciation	After tax savings after depreciation	Annual depreciation	Annual cash flow	Present worth factor at 5%	Present worth at 5%	Present worth factor at 8%	Present worth at 8%
1	7,000	2,025	2,950	4,975	0.9524	4,738	0.9259	4,606
2	7,000	2,025	2,950	4,975	0.9070	4,512	0.8573	4,265
3	7,000	2,025	2,950	4,975	0.8638	4,297	0.7938	3,949
4	7,000	2,025	2,950	4,975	0.8227	4,093	0.7350	3,656
5	7,000	2,025	2,950	4,975	0.7835	3,898	0.6806	3,385
6	7,000	2,025	2,950	4,975	0.7462	3,712	0.6302	3,135
7	5,000	1,025	2,950	3,975	0.7107	2,825	0.5835	2,319
8	3,000	25	2,950	2,975	0.6768	2,690	0.5403	1,607
9	1,500	725	2,950	2,225	0.6446	1,434	0.5002	1,113
10	500	1,225	2,950	1,725	0.6139	1,058	0.4632	799
Total	52,000	11,250	29,500	38,880	7.7216	33,257	6.7100	28,834

[a] Capital cost = $29,500. Ret. on inv. = 1125/29,500 = 4.2.%[d] Payoff = 7.4 yr.[d] Approx. return = 6.2%.[e]
[b] Capital cost = 29,500. Ret. on inv. = 1125/29,500 = 4.2%.[d] Payoff = 7.8 yr.[d] Approx. return = 5.6%.[e]
[c] Capital cost = 29,500. Ret. on inv. = 1125/29,500 = 4.2%.[d] Payoff = 5.9 yr.[d] Approx. return = 7.7%.[e] Present worth factor = 5%; present worth = 5%.
[d] Return if common method of computing is used.
[e] Return if discounted cash flow method is used.

No. 1 Requirement: Quality

Here's How a Mill Kept It... And Saved $.95 per Paper Ton!



Cash savings on size requirements multiplied by power savings, cleaner machines, better retention

Fine writing paper production can not take process short-cuts which affect quality . . . so this instance of Nalco Sodium Aluminate performance is more than a cost-cutting story—sheet specifications were considerably improved with Nalco 680 Sodium Aluminate—on top of all the other advantages!

Facts from Figures

This is the way the chemical costs work out on a "per ton" basis:

Size Requirements (without Nalco Sodium Aluminate)...	30.25 lb.
Size Requirements (with Nalco Sodium Aluminate)...	21.60 lb.
Pounds of Size Saved...	8.65
Alum Requirements (without Nalco Sodium Aluminate)...	40.00 lb.
Alum Requirements (with Nalco Sodium Aluminate)...	30.00 lb.
Pounds of Alum Saved...	10.00
Savings on Size (at 15.3 cents per lb.)...	$ 1.32
Savings on Alum (at 2.2 cents per lb.)...	.22
	$ 1.54
Less cost of Nalco Sodium Aluminate (at 10.7 cents per lb.)...	.59
TOTAL NET SAVING, per ton of paper	**$ .95**

Add to the dollar savings above: more fines and furnish kept in the sheet; more rapid reaction time to cut soluble alumina losses in the white water; higher pH to give means of adjusting size-alumina-pH ratio, and to cut corrosion damage; lower power requirements and cleaner machines.

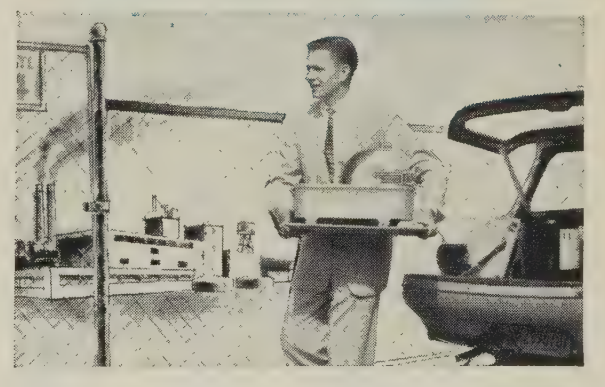
Nalco Sodium Aluminate is a concentrated package of stable, soluble alumina and alkalinity that produces positive advantages all along the line!

Paper Quality Improved

Nalco Sodium Aluminate not only produces spectacular figures in processing savings, but also improved sheet specifications in the mill whose alum-aluminate costs are given above: *Size ratings jumped from a range of 45-50 up to 50-60. Ash content went from 5.6-5.8% to 7-7.1%!*

Other quality improvements include: better aging, folding endurance, burst strength, workability and reduced brittleness.

Action When It Is Needed



Results with Nalco Sodium Aluminate—and every other Nalco chemical used in paper processing—are backed by Nalco Field Service Men whose experience and willingness to help can be of real value to you . . . whether the situation calls for emergency action or long-range planning for better paper products at lowest possible production costs.

For action that leads to results like these in your mill, call your Nalco Field Service Man, or write:

National Aluminate Corporation is now

NALCO CHEMICAL COMPANY

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Subsidiaries in England, Italy, Mexico, Spain, Venezuela and West Germany

In Canada—Alchem Limited, Burlington, Ontario

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...Serving Industry Through Practical Applied Science

Nalco CHEMICALS

The size of the annual repayment is determined from a present worth table (Table II). Such a table simply shows, in tabular form, the well-known fact that a dollar received a year from now is worth less than a dollar today, since if one had a dollar today he could invest it at interest and have more than a dollar in a year. That is, a dollar one year from now is worth only 95.2¢ today, if a 5% interest rate exists.

By adding up the present worth from Table II, it can then be seen that the present value of $1.00 received annually for 5 years, discounted at 5% is $4,329. It should be noted that the objective of the bank lending the $10,000 is to have the present worth of all future payments equal, at a 5% interest rate, to the $10,000 it is going to lend today. To obtain the annual payment rate, the bank needs only to divide the $10,000 by the present worth factor of $4,239 and the answer $2,309.75 is the annual payment for the next 5 years whose present worth at 5% is $10,000.

This situation is very similar to a capital investment in an industrial project, except that in the industrial case, the annual payments are known, since they are the annual cash flow from the project. The industrial objective is exactly the same; that is, to make the present worth of the cash flow equal to the capital investment. It remains then only to find the correct interest-rate table where the present worth of the cash flow equals the capital investment. This rate is then the true return on investment for the project.

Example 1 in Table III shows a typical project with a uniform annual cash flow of $4,075 per year. Using a trial and error approach, a 6% interest rate was first tried. The present worth of the future savings at 6% was $542 greater than the capital cost. A 7% rate was then tried, which yielded a present worth of the future savings of $28,628, or $872 below the capital. By interpolation the return on investment for this project is shown to be 6.3%. It is significant to note that one of the more common procedures would show a return of 4.2% and a payoff of 7.4 years.

Examples 2 and 3 in Table III show annual cash flows which vary over the life of the project, but are equal in total in each case. Example 2, where the savings are low in the initial years, shows a return of 5.6%, where as example 3, with low savings in the later years, shows a return of 7.7%. This illustrates the effect of time on the true rate of return of a project. It should also be noted that one of the common procedures would give a rate of 4.2% on each of these examples, although the payoff years would vary.

Table IV illustrates how capital expenditures in the later years of a project can be handled by the proposed procedure. The device to accomplish this is to simply compute the present worth of all the capital expenditures and find the interest rate that equates this to the present worth of the future savings. In this example, the rate is 29%. This compares with a return of 18.7% based on the previously mentioned "common procedure."

PART II

The first section of this paper dealt with the development of one figure which would represent the true rate of return on a given investment. This, however, turns out to be only the first step in solving the problem, since the rate obtained still does not show whether the return is satisfactory for the risk that may be involved. When we begin to try and evaluate risk, it is apparent that we begin to leave the realm of scientific, or objective, methods and enter into a more subjective, or intangible, means of evaluation. The fact that there are no absolute laws for evaluating risk should not

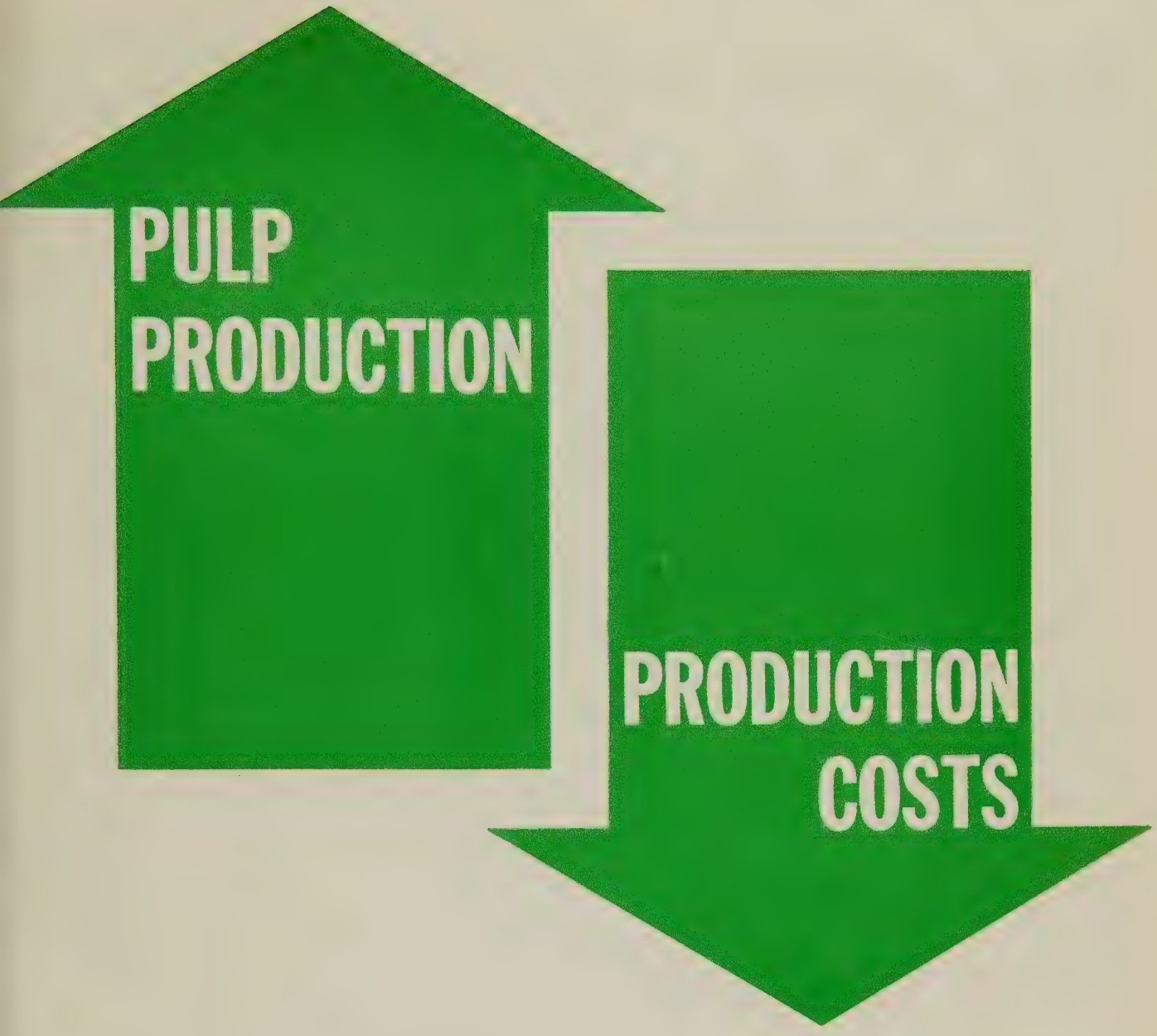
Table IV. Hypothetical Project Showing Effect of Capital Expenditures in Later Years of Project

Year	*Annual pretax savings before deprecation*	*After tax savings after depreciation*	*Annual depreciation*	*Annual cash flow*	*Present worth factor at 25%*	*Present worth at 25%*	*Present worth factor at 30%*	*Present worth at 30%*
1	20,000	7,000	3,000	10,000	0.8000	8,000	0.7692	7,692
2	20,000	7,000	3,000	10,000	0.6400	6,400	0.5917	5,917
3	20,000	7,000	3,000	10,000	0.5120	5,120	0.4551	4,551
4	16,000	6,000	4,000	10,000	0.4096	4,096	0.3501	3,501
5	16,000	6,000	4,000	10,000	0.3277	3,277	0.2693	2,693
6	16,000	6,000	4,000	10,000	0.2621	2,621	0.2071	2,071
7	15,500	5,500	4,500	10,000	0.2097	2,097	0.1594	1,594
8	15,500	5,500	4,500	10,000	0.1678	1,678	0.1226	1,226
9	15,500	5,500	4,500	10,000	0.1342	1,342	0.0943	943
10	15,500	5,500	4,500	10,000	0.1074	1,074	0.0725	725
Total	170,000	61,000	39,000	100,000		35,705		30,913

Year	*Future capital expenditure*	*Present worth factor at 25%*	*Present worth at 25%*	*Present worth factor at 30%*	*Present worth at 30%*
0	30,000	1.0000	30,000	1.0000	30,000
1	0	...	...	...	...
2	0	...	...	...	...
3	0	...	...	...	...
4	3,000	0.4096	1,228	0.3501	1,050
5	0	...	...	...	...
6	0	...	...	...	...
7	6,000	0.2097	1,258	0.1594	956
8	0	...	...	...	...
9	0	...	...	...	...
10	0	...	...	...	...
Total			32,486		32,006

Av. net savings = 61,000/10 = 6100; av. capital cost = (30,000 × 4 + 33,000 × 3 + 39,000 × 3) ÷ 10 = 33,600; ret. on inv. = 6100/33,600 = 18.2%[a]; payoff = 39,000/10,000 = 3.9 yr.[a]; approx. return = 29%.[b]

[a] Return if common method of computing is used. [b] Return if discounted cash flow method is used.



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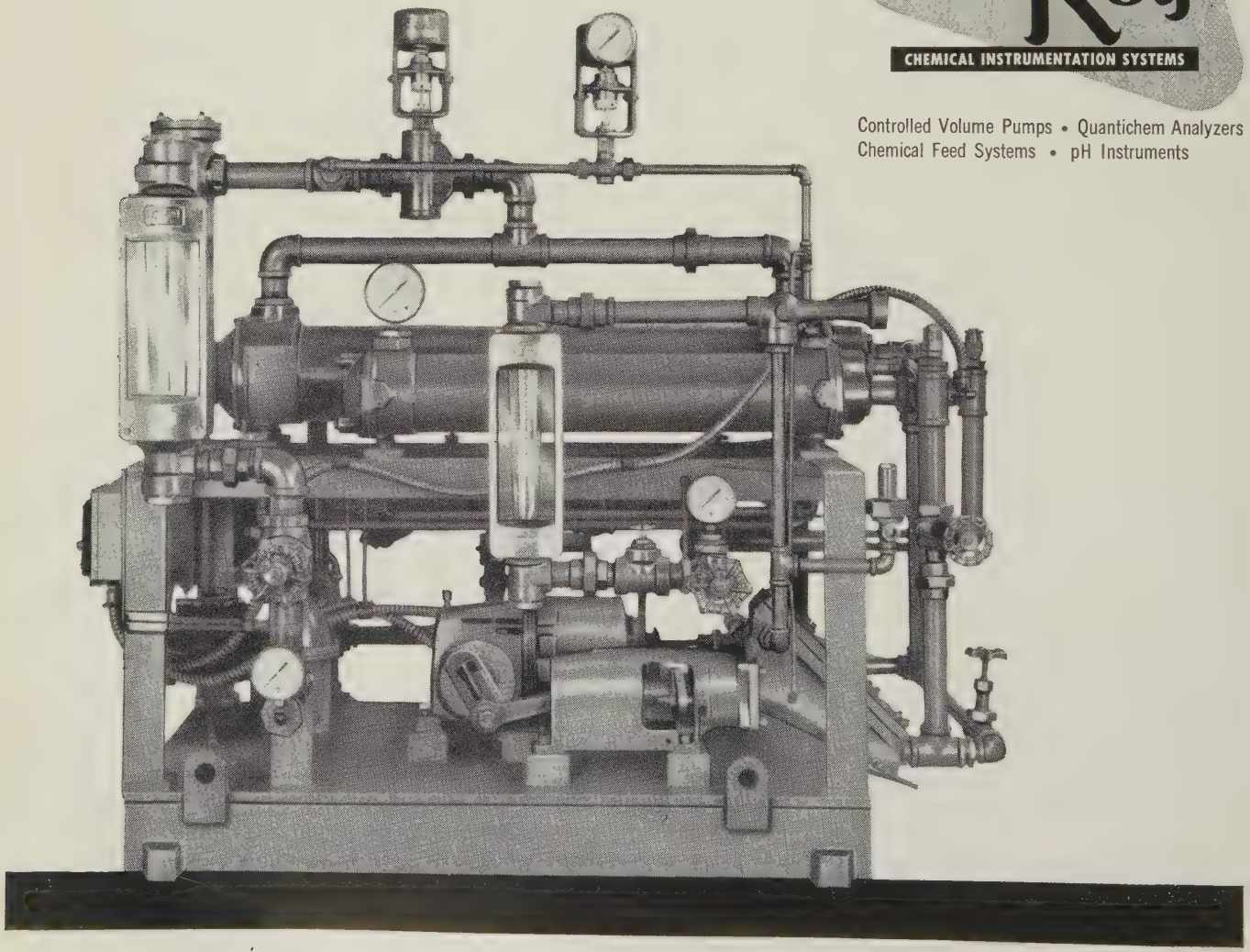

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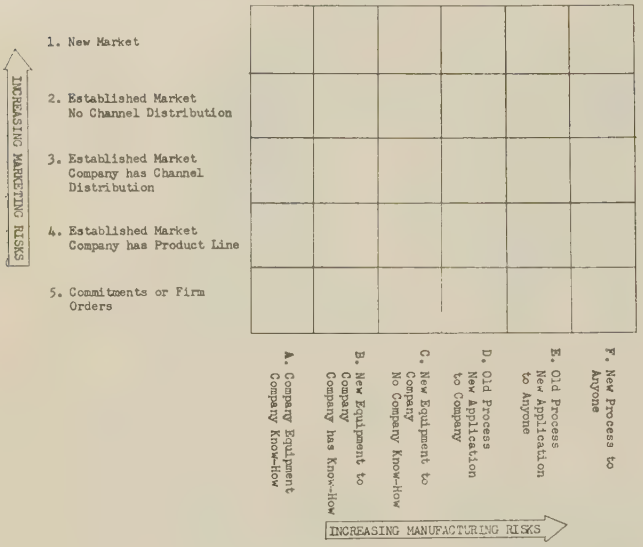
Table V. Minimum Rate of Return Desired for New Projects Exhibiting Certain Marketing and Manufacturing Risk Characteristics


1. New Market
2. Established Market No Channel Distribution
3. Established Market Company has Channel Distribution
4. Established Market Company has Product Line
5. Commitments or Firm Orders
INCREASING MARKETING RISKS
A. Company Equipment Company Know-how
B. New Equipment to Company Company has Know-how
C. New Equipment to Company No Company Know-how
D. Old Process New Application to Company
E. Old Process New Application to Anyone
F. New Process to Anyone
INCREASING MANUFACTURING RISKS

however, preclude introducing some sort of logical reasoning into the evaluation.

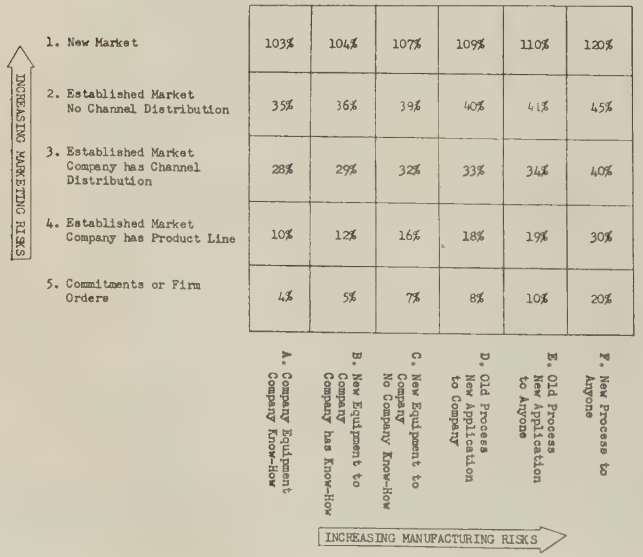
The risks of any new project normally can be divided into two groups, as follows:

1. Marketing Risks—Does the anticipated market exist, and can the product be sold successfully in the market?
2. Manufacturing Risks—Will the new process or equipment produce as expected?

In each of these two categories there are varying degrees of risk, and these have been shown in the form of a chart, or matrix, in Table V. The relative marketing risks are shown on the vertical scale, rising in order of increasing severity. Manufacturing risks are shown along the horizontal scale, with the higher risk factors extending to the right. Thus any project can be placed within the matrix by locating the intersection of rows describing the marketing and manufacturing factors involved.

Table VI. Minimum Rate of Return Desired for New Projects Exhibiting Certain Marketing and Manufacturing Risk Characteristics

(All % are based on after-tax figures)


1. New Market 103% 104% 107% 109% 110% 120%
2. Established Market No Channel Distribution 35% 36% 39% 40% 41% 45%
3. Established Market Company has Channel Distribution 28% 29% 32% 33% 34% 40%
4. Established Market Company has Product Line 10% 12% 16% 18% 19% 30%
5. Commitments or Firm Orders 4% 5% 7% 8% 10% 20%
INCREASING MARKETING RISKS
A. Company Equipment Company Know-how
B. New Equipment to Company Company has Know-how
C. New Equipment to Company No Company Know-how
D. Old Process New Application to Company
E. Old Process New Application to Anyone
F. New Process to Anyone
INCREASING MANUFACTURING RISKS

The next step is to assign some type of minimum return to each one of the squares in the matrix, so that if a project has certain manufacturing and marketing risk characteristics, management will know that the minimum return should be at least the figure shown in the appropriate square. Table VI shows how minimum after-tax rates of return might be assigned to each square. Obviously, projects involving the minimum risk (falling in the lower left hand corner of the matrix) need only a return slightly greater than the cost of borrowed money to be attractive.

Obtaining the figures for the other squares is somewhat more difficult, and depends on a combination of logic and individual company experience. Let us assume, for example that a company introduces five new products a year of a nature classed in category 1-F. Let us also assume that each of these products has a $100,000 investment. Now if only one of these five is a success, and the others fail to the extent of losing 60% of their investment, it is apparent that the successful product should return this lost $240,000 over its life, and at the minimum borrowing interest rate. The net effect of this is to substantially increase the return that must be required of high risk projects.

It is apparent from the above that the rates used will vary widely from company to company, depending primarily on how complete a development job is done on a new product or process before large investments are made. The rates in the matrix will also vary with the effectiveness of the firm's marketing, production, and engineering groups. While the previously mentioned four failures in five may appear high to many persons, this is the actual rate found by Joel Dean of Columbia University in a study of 200 new products introduced in recent years. (See Dean's book "Managerial Economics.") Since far more new products fail due to marketing factors rather than production factors, the returns required for products involving completely new markets should be substantially higher than for products where existing markets and channels of distribution exist.

The significance of developing this type of matrix is not so much that the per cent returns figures shown will be completely accurate, but that it will over a period of years provide an excellent frame of reference in evaluating the acceptability of various rates of return on new products. In addition, it will help point out the value and savings possible through more complete product development and economic analysis of new projects *before* expenditures are made.

PART III

Any system for evaluating the relative desirability of projects is only as good as the data used in calculating the costs and savings. For this reason, let us look at the details of an actual justification of an item of carton printing equipment.

In this particular case, let us assume for a hypothetical company that the present method of imprinting cartons was to use a small one-color flat bed printing press, which produced approximately 1500 cartons per hour while running. The average make-ready time to prepare the press for running a job was, on the average, about 20 minutes. These figures could be obtained from time standards developed by the plant industrial engineering department based on time study

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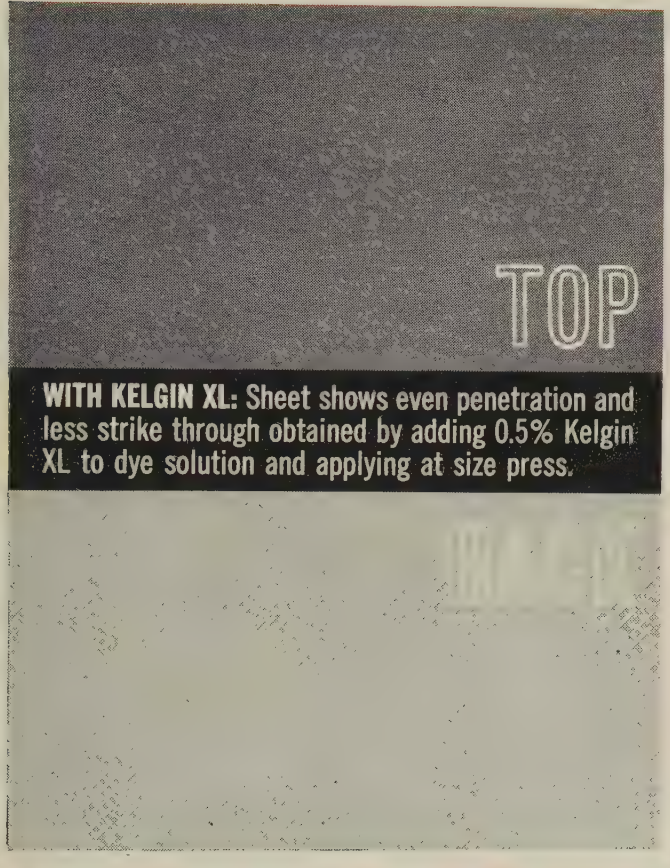
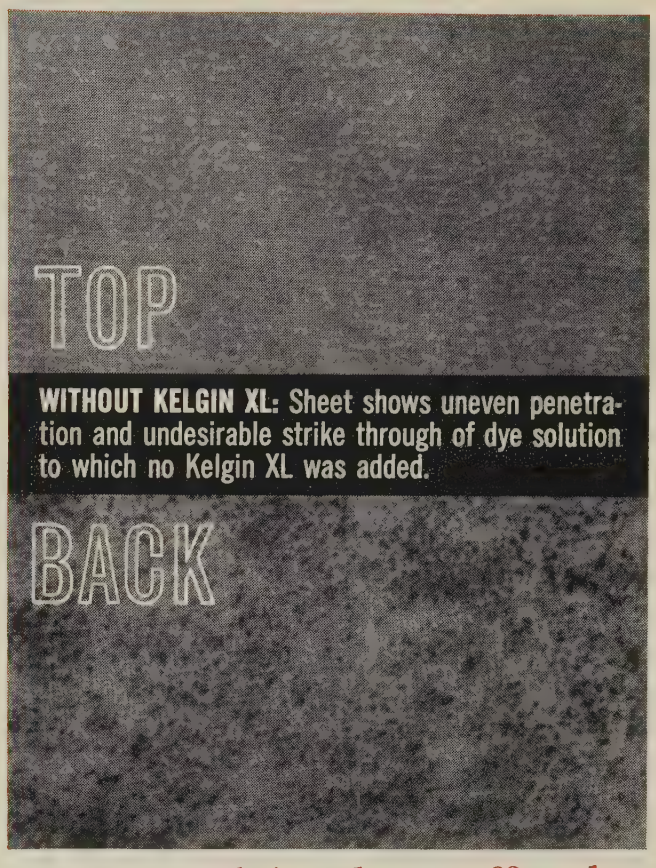


WITH KELGIN XL: Sheet shows even penetration and less strike through obtained by adding 0.5% Kelgin XL to dye solution and applying at size press.



WITHOUT KELGIN XL: Sheet shows uneven penetration and undesirable strike through of dye solution to which no Kelgin XL was added.

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Table VII. Determination of Savings and Machine Hour Rates

I. Out-of-Pocket Rates (Source)

	Present	*Proposed*
Wages	$2.27	$2.27
Fringe benefits	0.40	0.40
Power	0.05	0.03
Maintenance, labor and material	0.25	0.07
Total ($/operating hr.)	$2.97	$2.77

II. Estimated Volume for New Press (Based on analysis of run sizes of current and projected volume)

Av. impressions/hr. 3000
Av. impressions/order 3000
Av. make-ready/order ..... 1/3 hr.
Operating hr./wk. ..... 115 hr./wk.
1/3 hr. · x + (3000 x/3000) ..... 115 hr.
x (No. of orders/wk.) = 87 orders/wk. consisting of 29 make-ready hours and 86 run-hours
Impressions/yr. = 77 hr./wk. × 52 wk. × 3000 impressions/hr. = 12,000,000 impressions

III. Computation of Annual Savings

A. Present Method
Out-of-pocket cost/hr. = $2.97
Av. running speed = 1500
Run cost/impression = 2.97/1500 = $0.00198/impression
Annual run cost = 0.00198 × 12,000,000 impressions = $23,800/yr.
Annual make-ready cost = 2.97/hr. × 1/3 hr./order × 87 orders/wk. × 52 wk. = $ 4,870/yr.
Total Annual Cost = $28,270

B. Proposed Method
Out-of-pocket cost/hr. = $2.77
Av. running speed = 3000
Run cost/impression = 2.77/3000 = $0.000925/impression
Annual run cost = 0.000925 × 12,000,000 impressions = $11,100/yr.
Annual make-ready cost = 2.77/hour × 1/3hr./order × 87 orders/wk. × 52 wk. = $ 4,180/yr.
Total Annual Cost = $15,280

Net Annual Savings = $28,270 − $15,280 = $12,990 (First Year).

observations. If, however, this type of data was not available, past average production data for previous years might be used. The disadvantage of the latter approach is that the present equipment might be capable of substantially higher rates of production, but the operator's productivity on the press might be low, and average production data would not indicate this.

The proposed equipment to replace the flat bed press was a small rotary letterpress, capable of running at a top speed of 4000 impressions per hour. The average speed was estimated at 3000 impressions per hour, to allow for unavoidable downtime, etc. The press used rubber plates, but the make-ready time was not expected to be substantially different than with the present flat bed equipment using metal plates. Analysis of the costs of purchased rubber and metal plates indicated that there was no substantial difference in the price of the two types, when amortized over the anticipated life of the plates.

With this initial production information in hand, it then is necessary to compute the annual costs and savings. At this point, it should be emphasized that the only real savings are normally those which could be called "out-of-pocket" savings. These include reduced wages and fringe benefits, power costs, maintenance labor and material, spoilage, etc. Rarely does a new piece of equipment change the overhead costs, so that, although a machine may have a rate of $20 per hour for job costing purposes, only $10 of this rate might be considered "out-of-pocket." In this case, the hourly rates for the present and proposed methods are as shown in Table VII. Shown also in Table VII are the calculations used to arrive at the annual volume of work to be run on the new press and the annual "out-of-pocket" production savings possible with this volume.

In Table VIII the present value of this future stream of "out-of-pocket" savings is then compared, at various interest rates, to the initial cost of the new equipment, as described in Part I of this paper. In this example, the correct interest rate turns out to be *28%*, and this represents the true return on investment. In making this computation, it was assumed that the proposed $25,000 press would have an economic life of ten years, and that the "sum of the digits" method would be used in depreciating the asset. In addition, the annual savings were decreased by $200 per year to take into account increasing maintenance and updating costs as the press aged.

To compare this figure with the minimum desirable rate, the degree of manufacturing and marketing risks involved must be ascertained. In this case, we estimate the marketing risk as a Class 5 (Commitments or Firm Orders), since the volume handled by this press is only a small part of the volume that could be run on the press. In addition, there is little likelihood that the overall volume of this type of work will, in the foreseeable future, shrink to a point where the press could not be operated at the volume level anticipated.

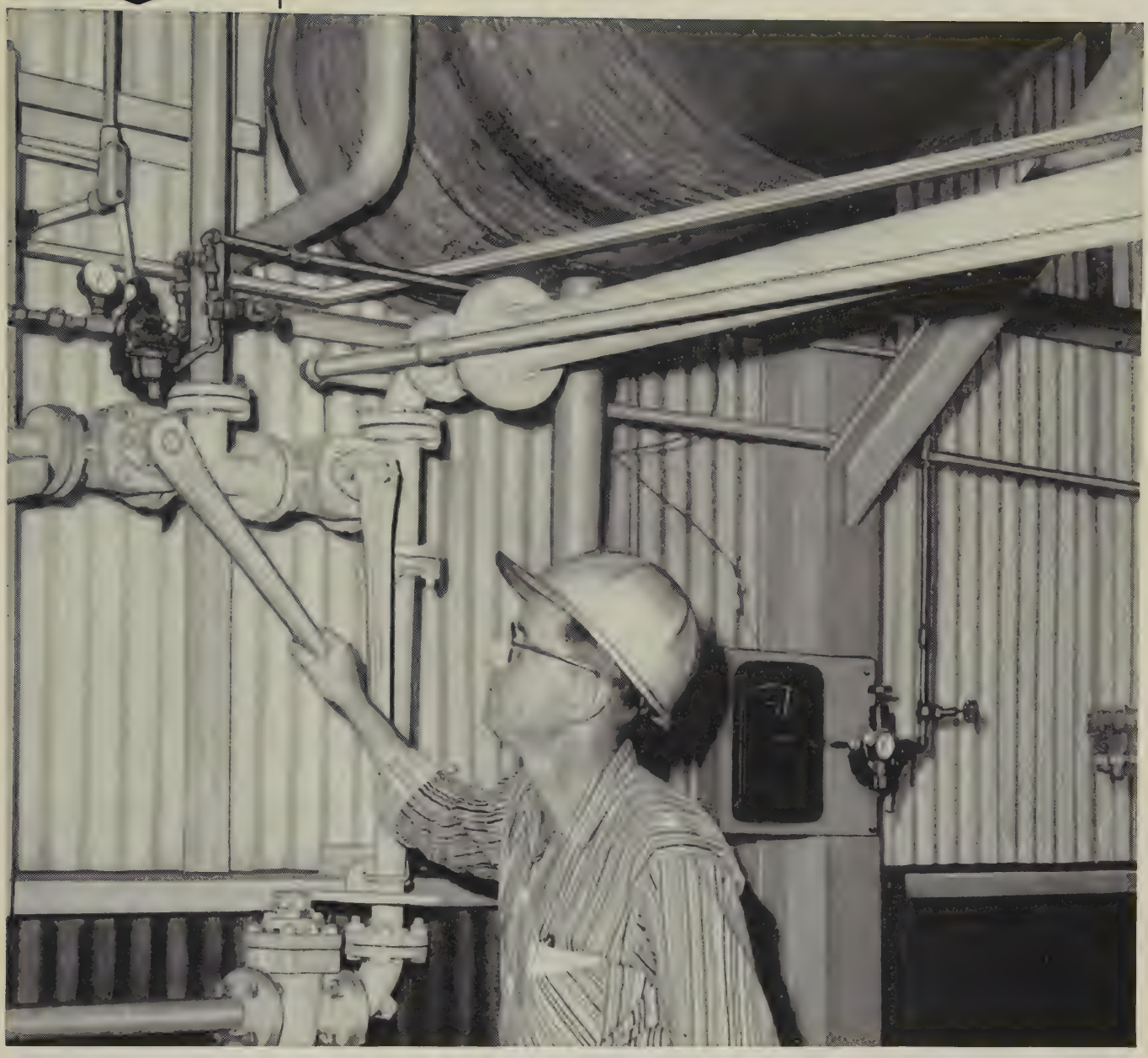
Since this is assumed to be a new type of equipment for our hypothetical company, but an established piece of equipment in the industry, we will call the manu-

Table VIII

Year	*A Annual pretax savings before depreciation*	*B Annual depreciation (sum of digits)*	*C After-tax savings after depreciation (52% tax)*	*D Annual cash flow (col. B + col. C)*	*E Present worth factor at 25%*	*F Present worth at 25% (col. D × col. E)*	*G Present worth factor at 30%*	*H Present worth at 30% (col. D × col. G)*
1	$12,990	$4,550	$4050	$8600	0.8000	$6,880	0.7692	$6,615
2	12,790	4,080	4180	8260	0.6400	5,286	0.5917	4,887
3	12,590	3,630	4300	7930	0.5120	4,060	0.4551	3,609
4	12,390	3,180	4430	7610	0.4096	3,117	0.3501	2,664
5	12,190	2,730	4540	7270	0.3277	2,382	0.2693	1,958
6	12,090	2,280	4720	7000	0.2621	1,835	0.2071	1,450
7	11,890	1,820	4830	6650	0.2097	1,395	0.1594	1,060
8	11,790	1,360	5010	6370	0.1678	1,069	0.1226	781
9	11,590	910	5120	6030	0.1342	809	0.0943	569
10	11,390	460	5250	5710	0.1074	613	0.0725	414
Total		$25,000				$27,428		$24,007

Av. return = 0.25 + (27,428 − 25,000)/(27,428 − 24,007) × 0.05 = 0.25 + 0.035 = 0.285 = 28 1/2%.

DOW | SARAN LINED PIPE



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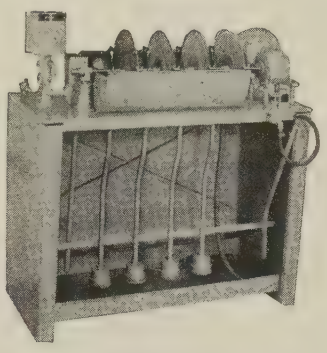

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facturing risk a Class C (New Equipment to Company —No Know-How). The block in Table VI where a Class 5 marketing risk and a Class C manufacturing risk intersect shows a minimum desired return of 7%. Since this is substantially less than the per cent we have shown, the press should actually return, it would appear desirable for the company to purchase this piece of equipment.

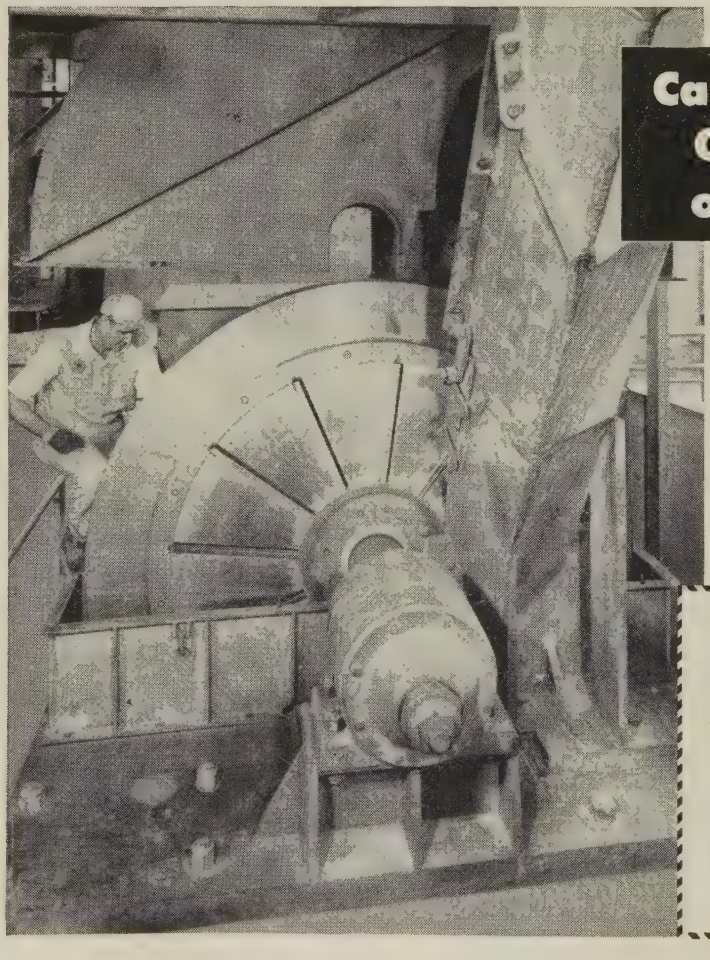
SUMMARY

The following are the key points relating to the justification of capital equipment.

1. The procedure for computing return on investment should show a true interest rate, should be able to compensate for irregular savings or additional expenditures in future years, and should give consistent results regardless of the size or duration of the project.
2. Some means of evaluating risks should be used so that this element can be taken into consideration.
3. The figures used in computing savings should be as accurate as possible, and should normally reflect reductions in "out-of-pocket" costs only.

While following the above suggestions will be of great assistance in evaluating capital expenditures, it should be borne in mind that no system will ever automatically make management's decisions. However, lack of a system may reduce the average percentage of good decisions that are made, and it is the percentage of good decisions that ultimately make a company a leader in its field.

Presented at the 14th Annual TAPPI Engineering Conference, Pittsburgh, Pa., Oct. 13, 1959.



Carthage-Norman Chippers Give You Greater Yield of Higher Strength Pulp

With its unique helicoidal disc segments and variable-bevel knives, the Carthage-Norman Chipper produces the highest percentage of "to size" chips. There are fewer compressed or bruised chips and ½% to 1% less sawdust — a feature which can pay for the chipper in one year. Knives wear longer — cost less. Heavy-duty construction results in exceptionally low maintenance costs.

SEND THE COUPON TODAY

CARTHAGE MACHINE CO.
CARTHAGE, NEW YORK
Please send full details showing why a Carthage-Norman Chipper will give me a greater production of uniform, clean-cut, "to size" chips.

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WHEN YOU HAVE A PROBLEM WITH PULP CHEMICALS, WE CAN HELP. WITH TRAFFIC, FOR EXAMPLE. Our traffic staff can work closely with yours to make sure that deliveries are made in a way to keep your inventories at a minimum without interrupting production schedules.

This cooperative effort in keeping inventories down has made it possible for our customers to save thousands of dollars in our more than fifty years of business with the pulp industry. Just ask when you want help.

The CAUSTIC SODA BUYER'S GUIDE is a compact source of information for anyone who buys or uses caustic soda. It gives full particulars on physical and chemical properties, shipping methods and containers, the economics of different strengths and grades, and the like. Write for a copy.

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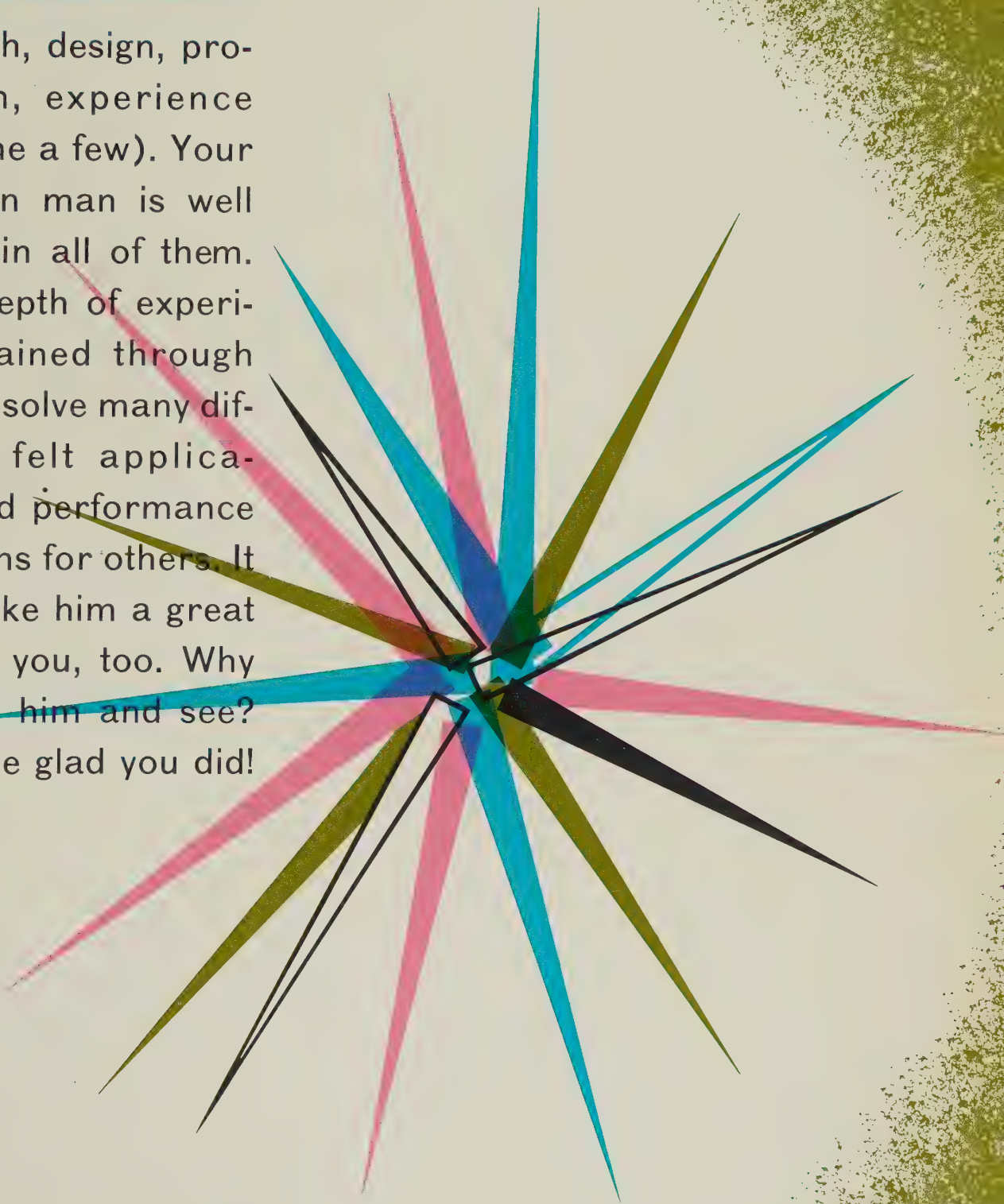

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Appleton Woolen Mills

Working With The Paper Industry

Appleton, Wisconsin

U.S.I. CHLORINE and CAUSTIC SODA

. . . from Huntsville, Alabama

Two U.S.I. plants, conveniently located at Huntsville, Alabama, can now supply your chlorine and caustic needs.

Make U.S.I. *your* preferred supplier of these paper chemicals. Here are some profitable reasons why you should:

- Your orders will arrive at a U.S.I. plant almost as soon as they leave your own—through U.S.I.'s automated order-handling system based on an extensive teletype network.
- Your orders will be delivered rapidly and without complications — because of the convenience of the Huntsville location and the efficiency of the order-handling system.
- You'll be working with a 50-year old chemical manufacturing company with a reputation of service to its customers throughout that half century.
- You'll be working with a large and continually-growing company that today has warehouses, plants and sales offices in 27 locations across the nation.

Liquid chlorine is shipped from Huntsville in tank cars. Commercial grade 50% liquid caustic soda is shipped in tankcars, tank trucks, barges. Other U.S.I. plants supply sodium peroxide, ammonia, polyethylene.

The coupon below provides a convenient way to find out more about U.S.I.'s supply and service capabilities. Why not drop it in the mail now while you think of it?

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We'd like to know more about U.S.I.

- ☐ Send brochure "National Distillers Expands in the Chemical Industry"
- ☐ Send information on your Automated Order Handling System
- ☐ Have a salesman call for an appointment to discuss chlorine and caustic soda
- ☐ Put me on your mailing list

Name_____

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U.S.I. INDUSTRIAL CHEMICALS CO.
Division of National Distillers and Chemical Corp.
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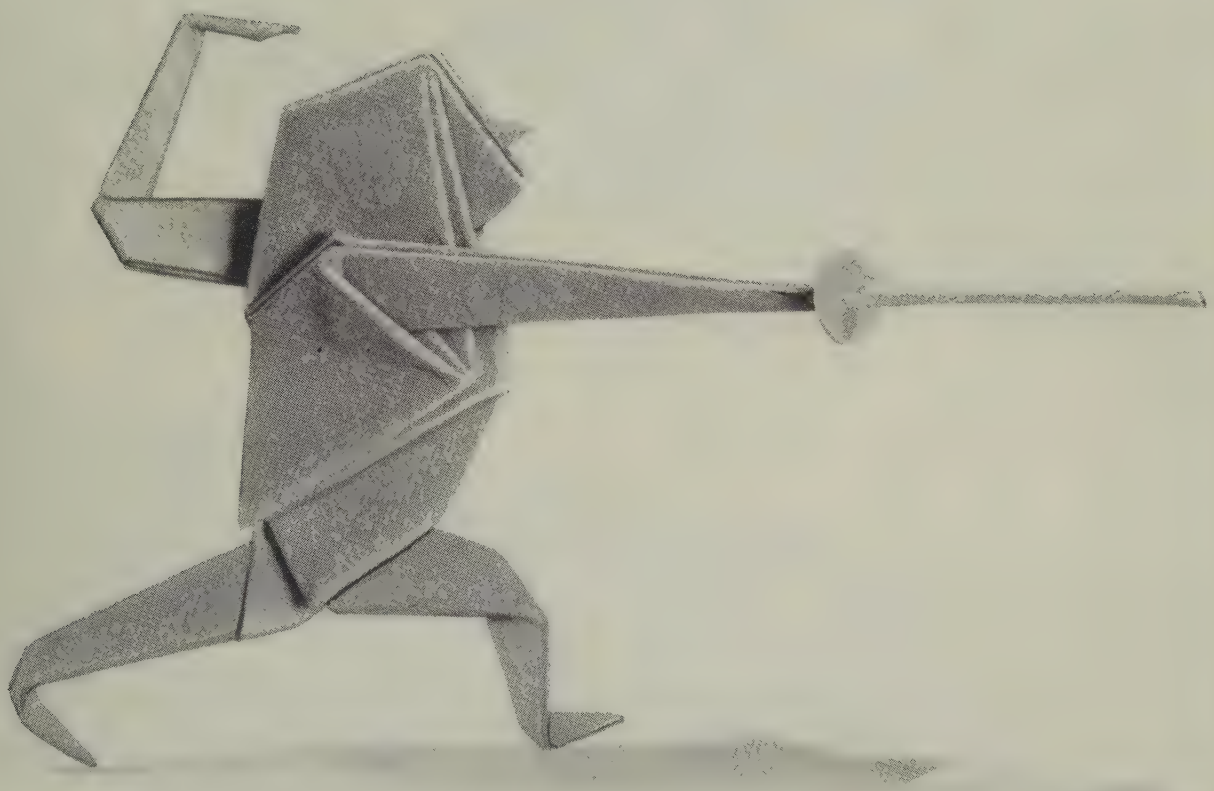
Paper sculpture by Giuseppe Baggi



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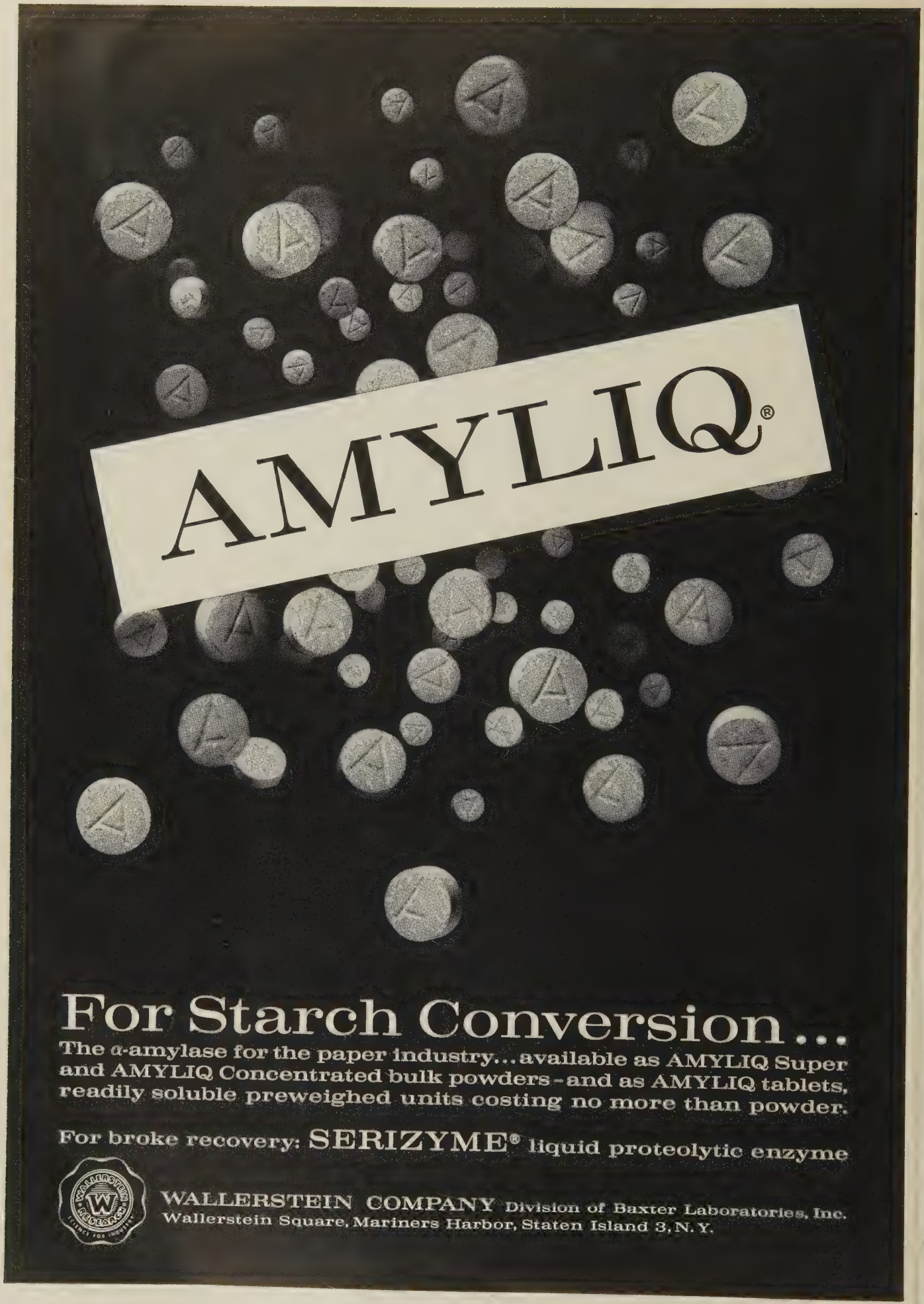
Gottesman & Company Aktiebolag, Stockholm, Sweden • Central National-Gottesman Limited, London, England • Representatives in 55 Leading World Markets



For Starch Conversion...

The α-amylase for the paper industry... available as AMYLIQ Super and AMYLIQ Concentrated bulk powders - and as AMYLIQ tablets, readily soluble preweighed units costing no more than powder.

For broke recovery: SERIZYME® liquid proteolytic enzyme

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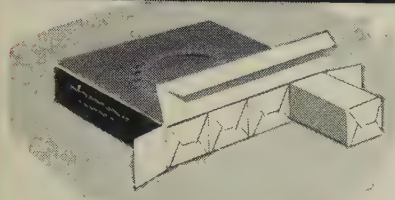
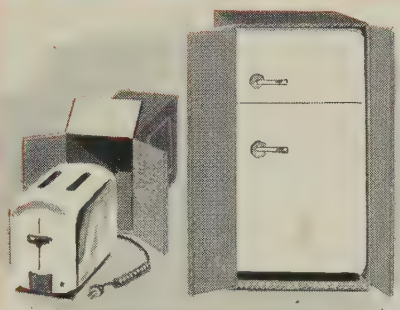


BUTTER, OLEO

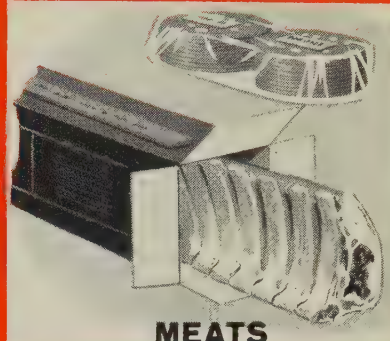
NUT MEATS

MILK, JUICE

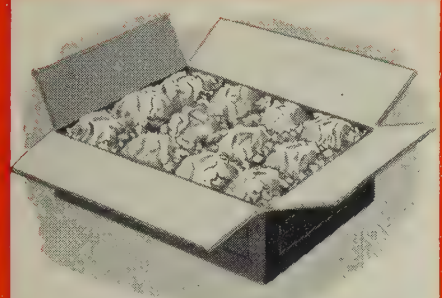
FURNITURE



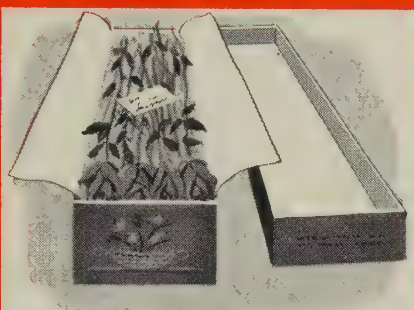
APPLIANCES



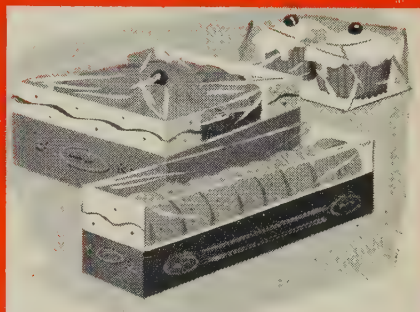
MEATS



FRESH VEGETABLES



FLOWERS



PASTRY

A-C® Polyethylene

CARTON COATINGS OFFER 7-WAY PROTECTION

- No more fiber scratch
- Improved scuff resistance
- Higher chemical resistance
- High grease resistance
- Better gloss
- Moisture resistance
- Reduced rub-off

If grease, moisture or fine finishes present packaging problems for your product, here's how you can pack and ship them safely *without recourse to costly carton liners:*

Incorporate A-C Polyethylene into your present carton-coating operation! It will eliminate fiber scratch and scuffing, give your cartons adequate resistance to grease, water and chemicals.

A-C Polyethylene can save you money, too. When you add it to ordinary wax coatings, *penetration is drastically reduced,* resulting in less wax consumption. For example, with straight paraffin, the normal coating weight is 7-8 lbs./1000 sq. ft. With addition of A-C Polyethylene, *it is frequently reduced to 3-5 lbs./1000 sq. ft. with superior protection!*

Write for literature, free samples. Free samples and technical data are now ready for your evaluation. Just write us at the address below. Or ask your local Semet-Solvay representative for a demonstration in your own plant. He can show you, right on your own equipment, how A-C Polyethylene can improve your cartons, save you money at the same time! *Contact us for the names of processors in your area who make up blends of A-C Polyethylene and wax.*

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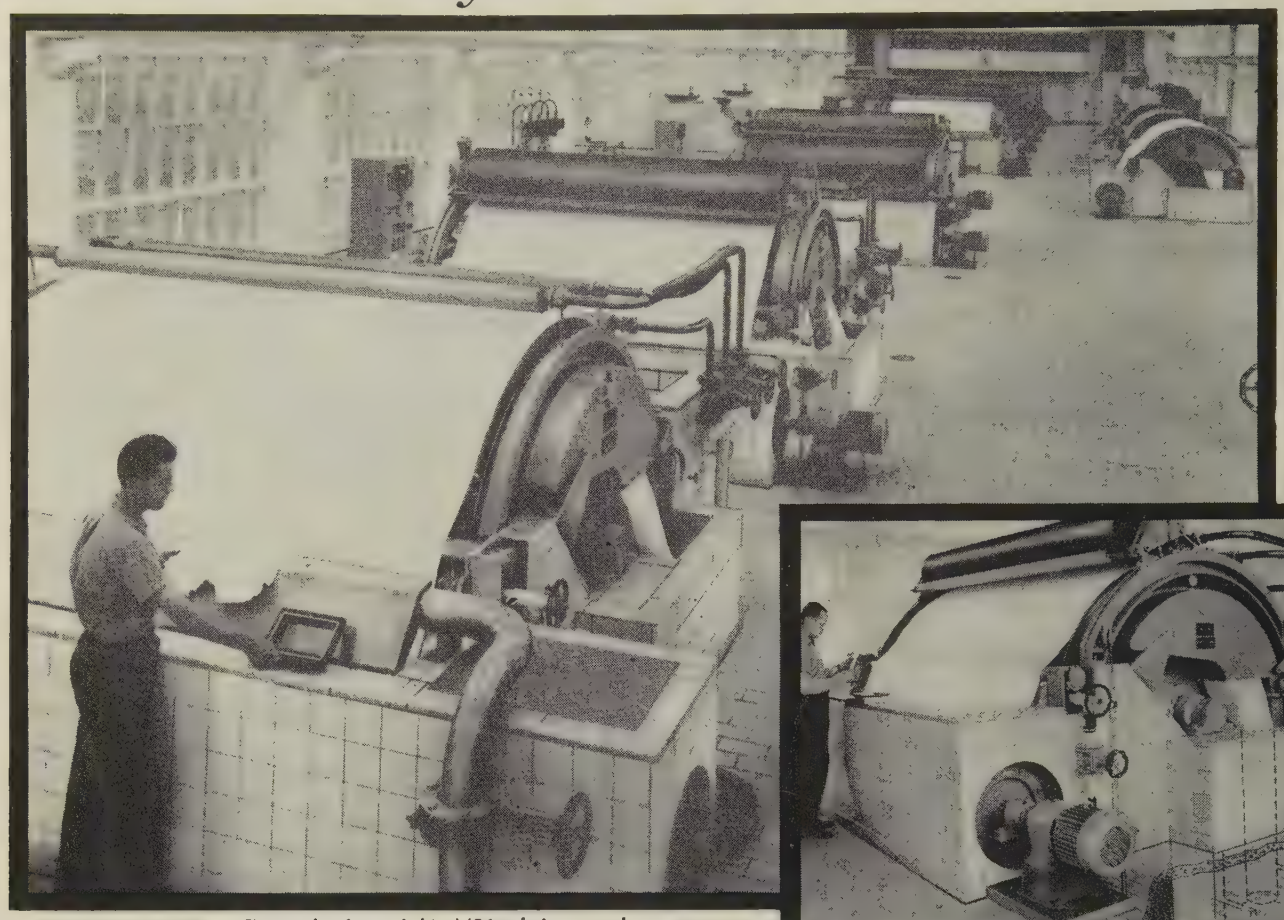
12 BIG REASONS
why KAMYR leads the field



Washer floor showing eight M54s being used as washers and three M54s being used as thickeners

M54 Kamyr vacuum washer with cutaway drawn to show seal box and short drop leg

More than 200 new M54 KAMYR vacuum washers installed since 1954!

Here's why:

1. Greater capacity
2. Lower power requirements for white water recirculation
3. Lower white water piping costs
4. Excellent sheet formation
5. Uniform washing action
6. Utilizes full indicated vacuum
7. Excellent pick-up
8. Excellent pick-off
9. Less foaming
10. Up to 30% consistencies when equipped with vacuum pump and press rolls
11. Mechanically simple
12. Easily installed

For full information on the design features which have produced these operating results, phone or write today.

THE
SANDY HILL
IRON AND BRASS WORKS
HUDSON FALLS, N. Y.

CALGON'S DISPERSIVE ACTION

NO CALGON—
there is no flow of the slurry containing low solids content
WITH CALGON—
the slurry flows readily with much higher solids content

most of the nation's leading producers of coated papers

USE CALGON®

in their coating formulas . . . shouldn't you?

Calgon's special properties fit the needs of the paper industry. The experienced assistance of Calgon Technical Service has helped solve many a knotty water problem for paper manufacturers. Here are some of the reasons why so many of the nation's paper manufacturers chose Calgon for coating colors:

Better pigment dispersion. Calgon has high efficiency as a dispersive of clay, titanium dioxide, precipitated calcium carbonate, and other pigments.

Better coating colors. With Calgon in the formula, flow properties are improved and higher solids concentration can be used.

Better surface coating. Adding Calgon to the coating formula greatly improves the bond between the coating and the paper stock.

Calgon can help in many other ways. If you have a specific problem, Calgon Technical Service will be glad to assist you in finding a solution. Let us know about your problem, or write for a copy of "Calgon and Its Applications in the Pulp and Paper Industry."

Calgon is the registered trade mark of Calgon Company for its sodium phosphate glass (sodium hexametaphosphate) products.

CALGON COMPANY
DIVISION OF **HAGAN** CHEMICALS & CONTROLS, INC.
HAGAN BUILDING, PITTSBURGH 30, PA.
In Canada: Hagan Corporation (Canada) Limited, Toronto

Clean water from Dorr Clarifier flows down aeration ladder on way to settling basin.

HOW DIAMOND GARDNER SOLVED EFFLUENT PROBLEM AT NEW PLANT *and won approval for site near river bank*

Diamond Gardner's new integrated forest products plant at Red Bluff, Calif., is a model installation for complete utilization of the timber harvest.

A sawmill produces lumber (90 million bd. ft. per year) from logs gathered at this central point, with bark and sawdust serving as fuel for the boiler plant. Sawmill residuals (slabs and edgings) are processed into pulp. The pulp mill's entire output goes to the molded products plant—the first big one on the Pacific Coast—for processing into food containers, plates, egg cartons and the like.

But before this model project could get off the drawing board, the company had to provide a plan for disposing of plant effluent that would win state approval. This was vital since the site is near the banks of the Sacramento River, and there could be no possibility of pollution by effluent.

Effluent Treatment Plant

The efficient waste treatment plant, designed by the company engineers, uses Dorr-Oliver equipment. Effluent from pulp and molding processes flows to a Dorr

Sludge from Clarifier is pumped to Oliver Vacuum Filter for dewatering prior to disposal.

Clarifier, where flocculants are metered in. The resulting water, of 25-30 alpha units turbidity, flows down aerating stairs en route to a three-compartment, 9¼-acre settling basin, becoming progressively clearer until it finally discharges into a seven-acre percolation pond. From here, it disperses underground.

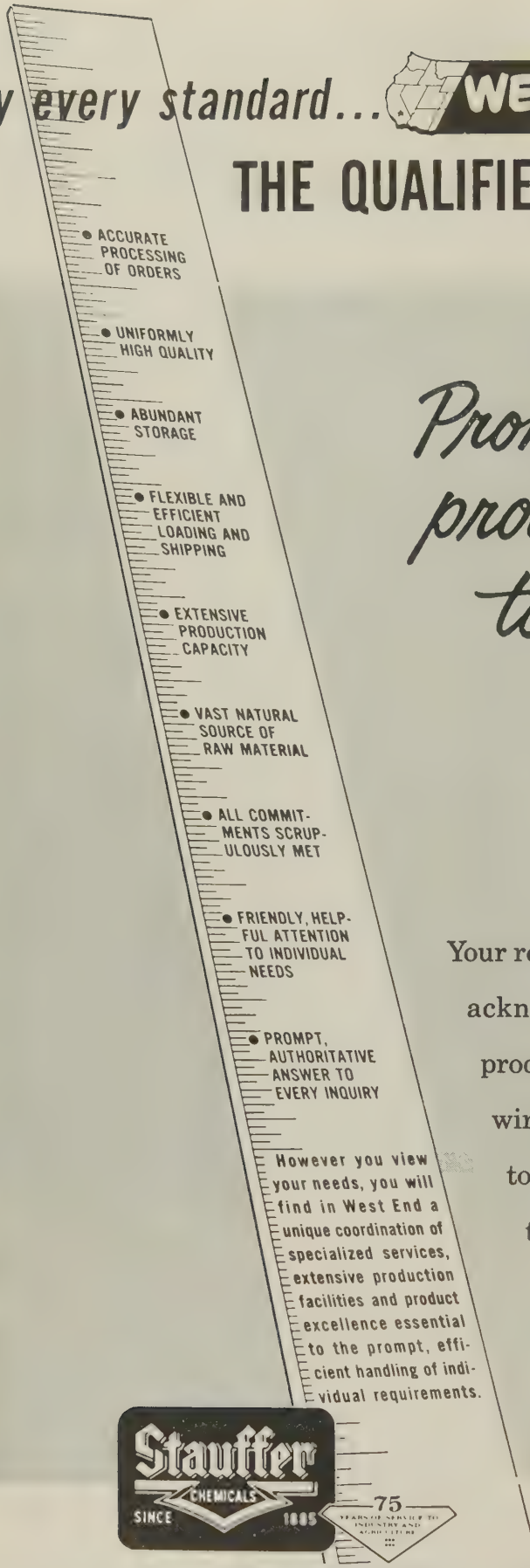
Sludge recovered from the Dorr Clarifier is fed to an Oliver rotary drum Vacuum Filter designed to operate either as a precoat unit or with roll discharge, similar to a pulp filter. Fibers and fine particles are removed as a mat for disposal.

According to the plant manager, the effluent treatment plant has proved highly effective. All tests to date indicate that the processed water meets state water pollution control standards.

Dorr-Oliver has a wealth of experience and diversified equipment to solve waste disposal problems of all kinds. For further information on how they can be put to work in your operations, write to Dorr-Oliver Incorporated, Stamford, Connecticut.

DORR-OLIVER
WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT

By every standard... WEST END MEASURES UP AS THE QUALIFIED SUPPLIER OF SALT CAKE


• ACCURATE PROCESSING OF ORDERS
• UNIFORMLY HIGH QUALITY
• ABUNDANT STORAGE
• FLEXIBLE AND EFFICIENT LOADING AND SHIPPING
• EXTENSIVE PRODUCTION CAPACITY
• VAST NATURAL SOURCE OF RAW MATERIAL
• ALL COMMITMENTS SCRUPULOUSLY MET
• FRIENDLY, HELPFUL ATTENTION TO INDIVIDUAL NEEDS
• PROMPT, AUTHORITATIVE ANSWER TO EVERY INQUIRY
However you view your needs, you will find in West End a unique coordination of specialized services, extensive production facilities and product excellence essential to the prompt, efficient handling of individual requirements.

Prompt, accurate processing of orders to last detail

Your requirements as to shipping dates, routing, acknowledgements, advices, scheduling and product specifications are relayed by private wire teletype from the Oakland Sales Office to the responsible plant personnel who see that orders are filled exactly as written.

Stauffer CHEMICALS SINCE 1885 — 75 YEARS OF SERVICE TO INDUSTRY AND AGRICULTURE

WEST END CHEMICAL COMPANY • DIVISION OF STAUFFER CHEMICAL COMPANY

1956 WEBSTER STREET, OAKLAND 12, CALIF • PLANT: WESTEND, CALIF.

...for papers that want to be READ!

Evidence exists that tinted papers with carefully color-correlated inks to reduce light reflectance ratios may increase reading speed and comprehension as well as reduce fatigue.

Inherent in these disclosures is a tremendous profit potential for papermakers. New values can be sold in colored papers for text and technical books, newsprint, annual reports, promotional pieces, periodicals of all kinds — in short any paper designed primarily to be read!

Your National Aniline representative is prepared to discuss the economics and other aspects of these new uses of color. We will also be glad to send reprints of an article on the subject by color expert Faber Birren. Ask for *The Age of Reason for Color.*

To demonstrate how readability can be improved through use of tinted stock, this advertisement is reproduced by letterpress on Impact Coral, Appleton Coated Sub. 80, Dull Finish, with correlated ink, Impact Maroon.

Four-color process is beautifully reproduced simply by substituting Impact Maroon to print the "black" plate. Red, yellow and blue are conventional process inks. Note how your eye sees "whites" in this picture.

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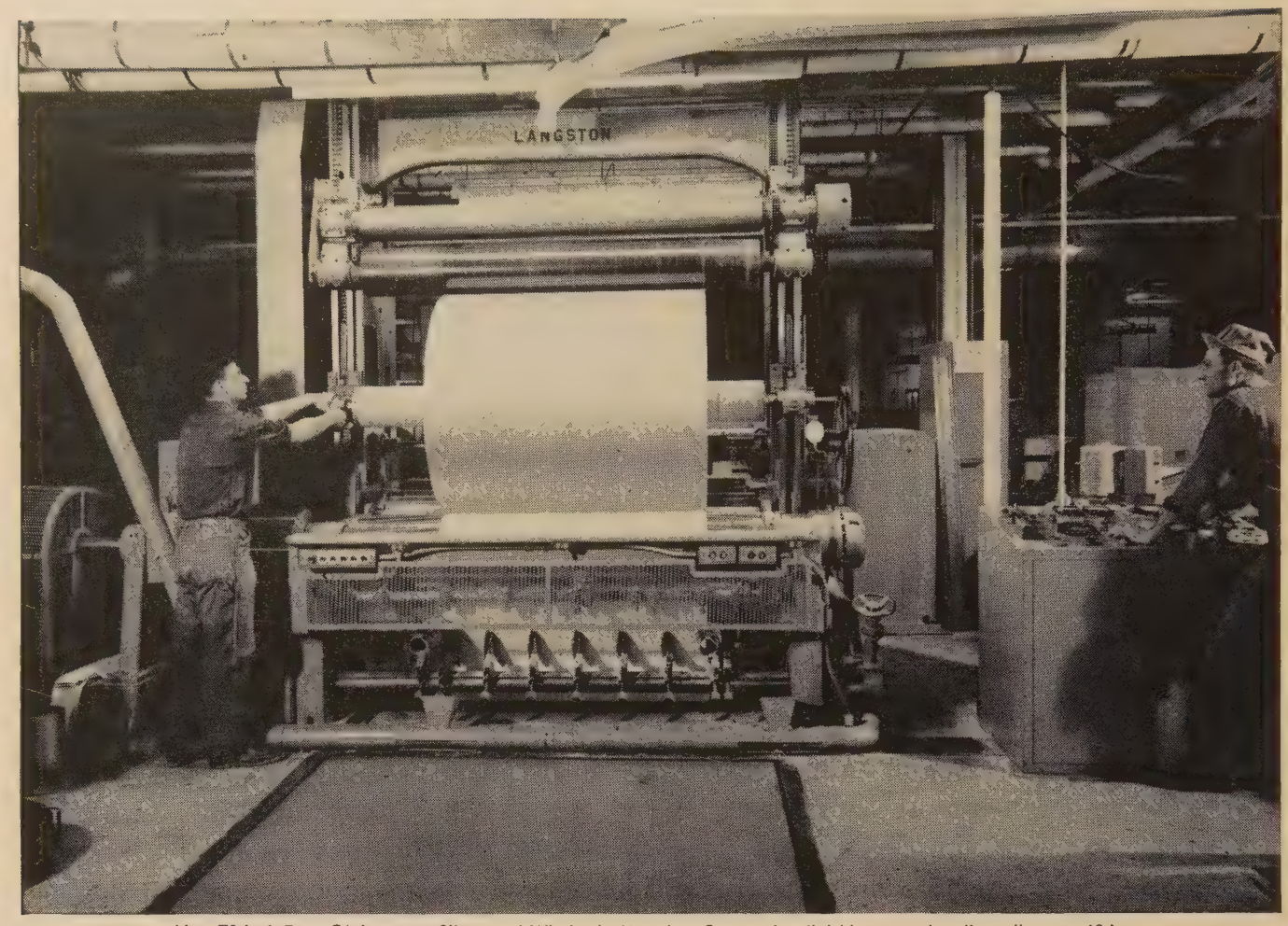


New 72-inch Type CA Langston Slitter and Winder in Marathon Corporation finishing room handles rolls up to 60 in. in diameter at speeds up to 1500 ft. per minute. Finished rolls are lowered by hydraulic drop shown in foreground.

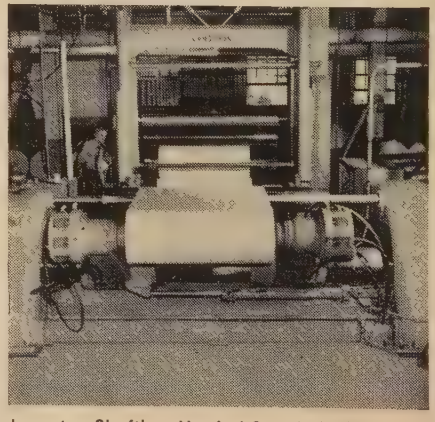
New Langston Slitter and Winder helps Marathon cut operating costs

This new Langston Slitter and Winder installation at Marathon Corporation's Rothschild, Wis., mill is already helping the company cut costs and speed processing of quality paper and board.

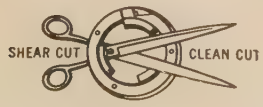
For example, the power-operated shaftless unwind stand virtually loads itself. No crew is needed to bull heavy shafts into place. And the Langston hydraulic roll ejector permits 1-man removal of finished rolls. These two features alone are saving Marathon several thousand dollars a year. Water-cooled Wichita-type air brakes can be operated from control console.

Besides effecting major operating economies, these Langston machines also pay off in higher quality rolls. The hydraulic rider roll control, for instance, automatically keeps nip pressure constant, regardless of the diameter or weight of the rewound roll. This insures rolls of uniform density with reduced tendency toward wrinkling or telescoping. The shear-cut slitters cut like scissors instead of a knife, shearing cleanly and keeping paper dust to a minimum. The resulting clean-edged, dustfree rolls are easier for customers to process.

Learn how you can benefit from the advantages of Langston Slitters & Winders. Write SAMUEL M. LANGSTON CO., 6th & Jefferson Sts., Camden 4, N.J.



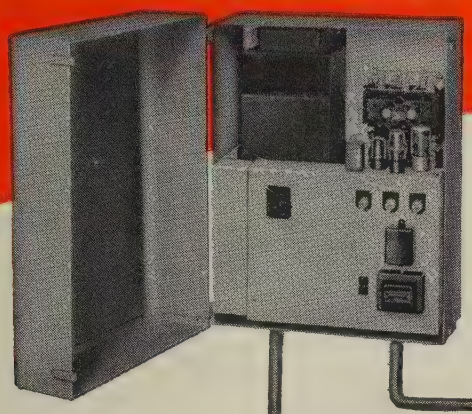
Langston Shaftless Unwind Stand eliminates the time-consuming, back-breaking task of hoisting heavy shafts into place. The hydraulically actuated arms reach out, pick up the roll and lift it to running position—a 1-man, push-button operation.



LANGSTON Leadership...by design

EATON
DYNAMATIC®

Drive Package Provides Infinitely Adjustable Speeds from AC Power Source



CONTROL PANEL

CONTROL STATION

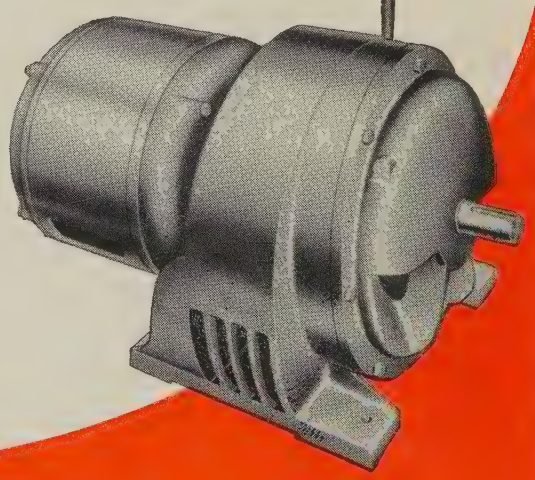
The complete Dynamatic power package includes all components required to provide infinitely adjustable speeds from an alternating current power source. A Dynamatic Ajusto-Spede® or Dynaspede® Drive, with electronic control and pushbutton station, satisfies the requirements of almost any application where proper machine operation or material processing depends upon control of operating speeds.

The compact control panel may be remotely mounted to conserve valuable space on the driven machine. The pushbutton station at the operator's position puts vital controls conveniently at the operator's fingertips and requires a minimum of space.

Speeds are infinitely adjustable from 0 RPM to full output speed, and accurate speed regulation may be obtained from 100 RPM to full output speed.

Ajusto-Spede® Drives, available in ratings of ¼ horsepower to 75 horsepower, are air-cooled. Dynaspede® Drives, rated from 3 to 75 horsepower, are liquid-cooled. Raise your productive efficiency with Dynamatic eddy-current units.

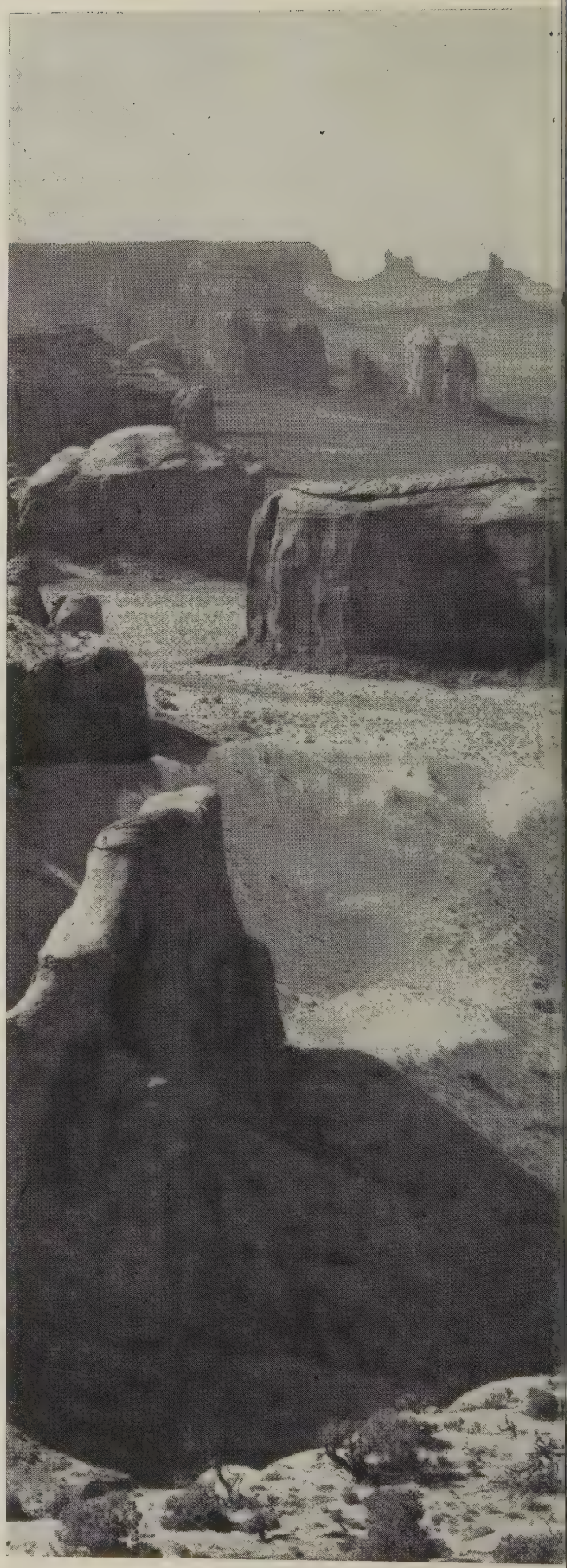
DYNAMATIC®
AJUSTO-SPEDE DRIVE



Send for Illustrated Literature Describing Dynamatic Adjustable Speed Drives

EATON
DYNAMATIC DIVISION
MANUFACTURING COMPANY
3307 FOURTEENTH AVENUE • KENOSHA, WISCONSIN

Hills and valleys may be beautiful... but not for paper coaters



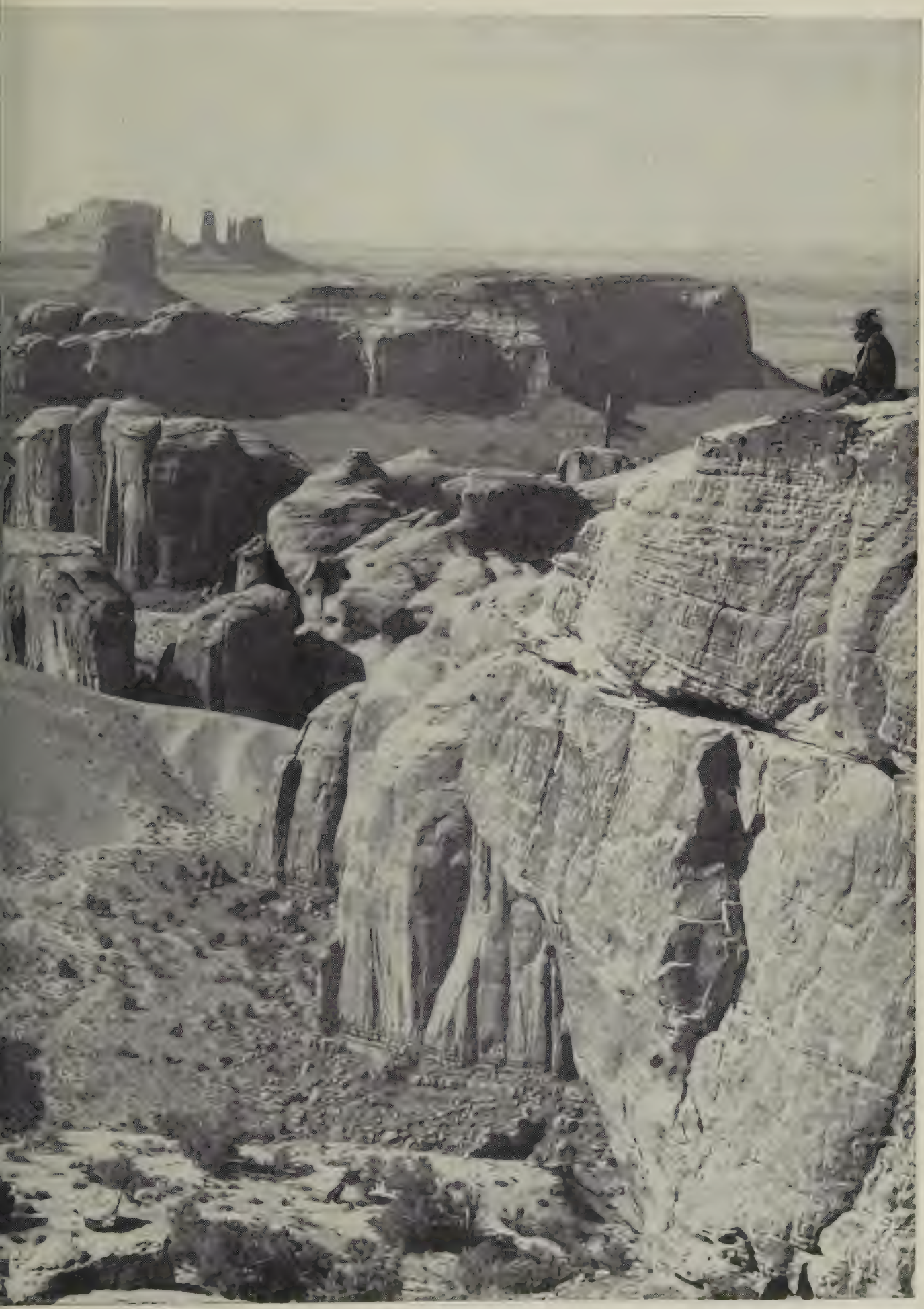
A paper coater might enjoy this view when he is on vacation, but "hills and valleys" are the last things in the world he wants in the paper he has coated. Perfect smoothness is his aim, and competitive tests indicate he has a better chance of getting it with DYLEX® K-54 latex.

DYLEX K-54 is a new Koppers latex for the paper coating industry. In Gurley Smoothness Tests on identical paper coated with a DYLEX K-54 formulation and competitive latices, the paper coated with DYLEX K-54 had substantially higher ratings at all adhesive levels. Both starch and casein were used in the tests.

In addition to superior smoothness, DYLEX K-54 offers higher pick resistance, excellent mechanical stability and less foam. For more information on formulating better clay coatings with DYLEX K-54, write for our free booklet. Koppers Company, Inc., Plastics Division, Dept. T-20, Pittsburgh 19, Pa.

KOPPERS PLASTICS

KOPPERS



STOP---

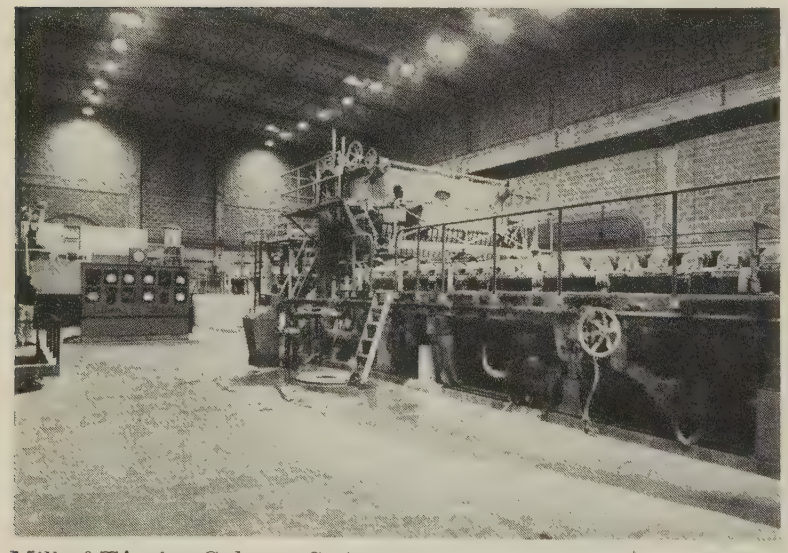
INVESTIGATE

The DE LA ROZA Bagasse Pulp and Paper Process

Every day more mill owners are finding INCREASED PROFITS by utilizing bagasse for the production of newsprint, book, bond and other paper and cellulose products.

Consider the following facts and investigate today:

- The de la Roza process is the only one that uses 100% bagasse fibre without the addition of wood pulp or other fibres—*all* the raw material is available at your mill.
- Only The de la Roza process uses pith fibre as well as long fibres of the bagasse—this supplies the required filler, improves formation and *lowers cost.*
- "Is the only process considered satisfactory in all signified respects for newspaper use." According to A STUDY OF NEWSPRINT EXPANSION, a process report by the United States Department of Commerce to the Committee of Judiciary, House of Representatives (U. S. Printing Office 1952).



Mill of Técnica Cubana, S. A., 300 tons daily ultimate capacity, designed, constructed and initially operated by de la Roza Corporation, WORLD'S LEADING BAGASSE ENGINEERS.

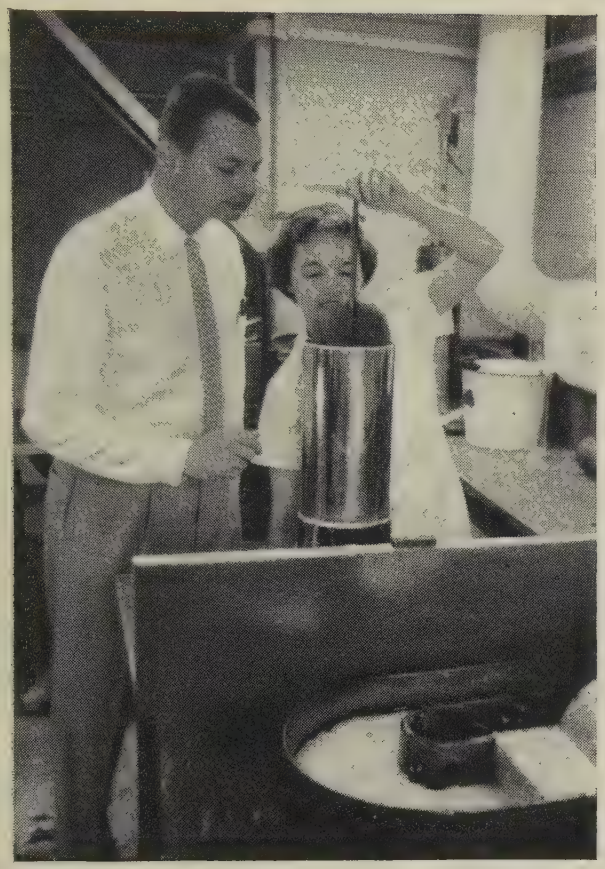
- There is no substitute for experience; the de la Roza process is producing on a successful commercial basis excellent newsprint and paper products at Técnica Cubana S.A.

The Pioneer in Bagasse Processing

DE LA ROZA
CORPORATION

441 Lexington Ave., New York, N. Y.

Solvay "Miniature Mill" helps customers improve pulps



Handsheet in process of manufacture from customer's pulp sample will be used for testing.

When you submit a pulp sample to Solvay for analysis, it is literally "put through the mill." Its fitness for the product you want to produce is determined in a laboratory mill that duplicates actual production conditions.

Solvay graduate engineers, versed in pulping, bleaching and papermaking, conduct these tests. They employ novel experimental techniques utilizing a wide variety of basic and advanced equipment to produce practical results for the industry. They can recommend the *best bleaching sequence* for a mill without prejudice. Solvay is actively interested in chlorine, chlorine dioxide, hydrogen peroxide and hypochlorite.

Write for information or technical aid in applying any of these bleaching agents or other Solvay® products listed.

Solvay Chemicals For The Paper Industry

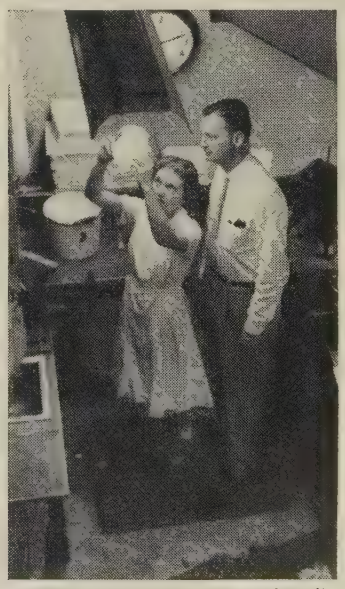
Caustic Soda	Hydrogen Peroxide
Chlorine	Soda Ash

Allied Chemical

SOLVAY PROCESS DIVISION
61 Broadway, New York 6, N. Y.

SOLVAY branch offices and dealers are located in major centers from coast to coast. Send export inquiries to Allied Chemical International, *40 Rector St., New York 6, N. Y.*

Wood chips (right) are resolved in the digester, then produced into fully bleached pulp (left) for handsheet test.



Inspection of handsheet reveals suitability for physical testing and cleanliness of pulp (presence of foreign dirt or unbleached fiber bundles).

Protect the other

What is *The New Roll?* It is a finished roll of superbly controlled quality, produced with matchless speed and efficiency on a completely integrated roll production system, engineered from unwind to rewind by the Cameron team of specialists.

THE BACKGROUND FOR TRULY INTEGRATED ROLL CONTROL

CAMERON BRAKES

Continuous duty pneumatic friction unwind brakes varying in capacity from 3 to 5 horsepower, on up to 360 horsepower, available in many different models and arrangements.

CAMERON UNWINDS

Shaftless and shaft-type unwind stands, including the shaftless automatic pickup type, all available in capacities to suit.

CAMERON CONSTANT TENSIONS

Several highly developed types including the pneumatic dancer roll type, and pneumatic-hydraulic and electric models, all featuring fast, sensitive response; all available with electronic or air-operated side register controls.

CAMERON MILL TYPE WINDERS

Two-drum surface wind, and surface-center wind models, each available in several series, including the famous Cameron Imperial, world's fastest heavy-duty mill-type winder. The complete Cameron line includes winders and slitter-rewinders to meet every mill and finishing room requirement.

OPTIONAL EQUIPMENT

Optional Cameron equipment, designed to save time and minimize damage, includes automatic shaft injectors, shaft pullers, core loaders, roll ejectors and roll unloading tables.

ACCESSORIES

Cameron accessories include pneumatic score-cut, shear-cut and special slitter elements, slitter wheels, slitter wheel grinders, core cutters, etc.

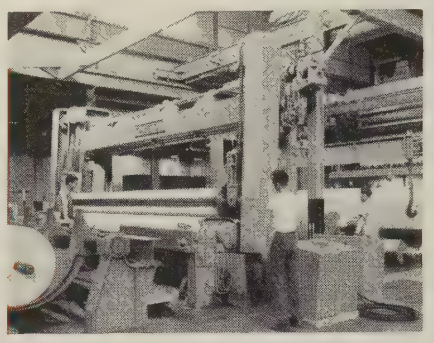
PNEUMATIC SHAFTS

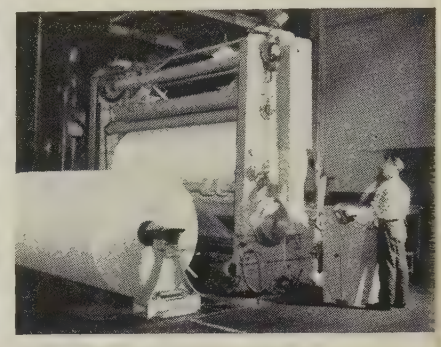
Famous custom-built TIDLAND pneumatic shafts for all types of roll winding and unwind service are sold *exclusively* by Cameron.

In addition to equipment for paper and paperboard mills, Cameron designs and builds a complete line of roll production equipment and roll controls for paper, film and foil converters, textiles, rubber and hundreds of miscellaneous industrial applications.

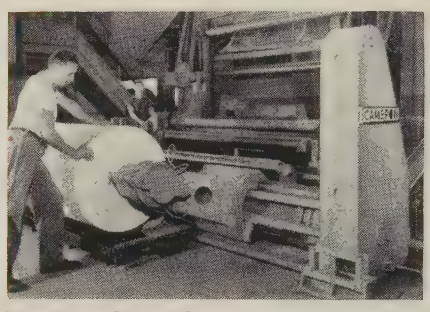
CAMERON

a team of specialists

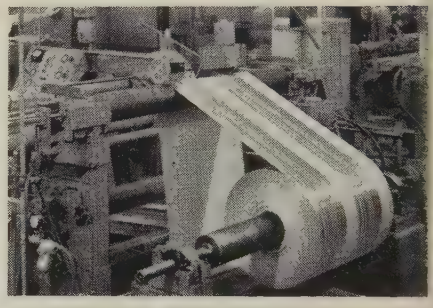




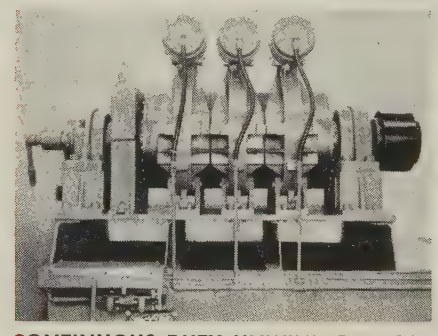
MILL TYPE WINDERS FOR PAPER AND PAPERBOARD



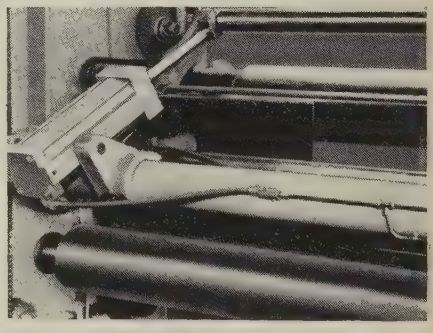
UNWIND STANDS



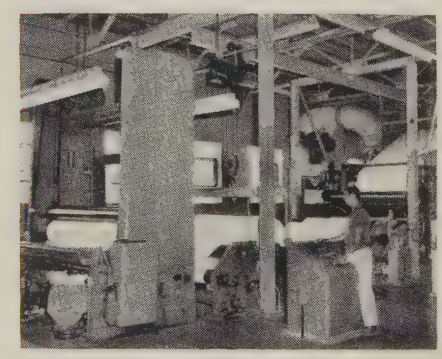
CONSTANT TENSION SYSTEMS

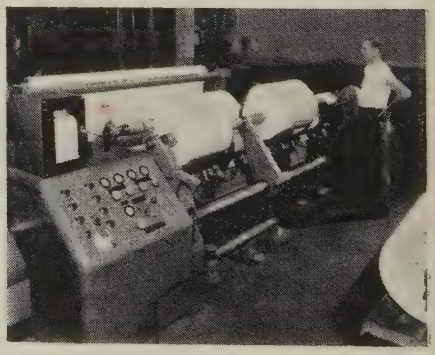


CONTINUOUS DUTY UNWIND BRAKES



ROLL EJECTORS, ETC.





ROLL PRODUCTION EQUIPMENT FOR FINISHING AND CONVERTING

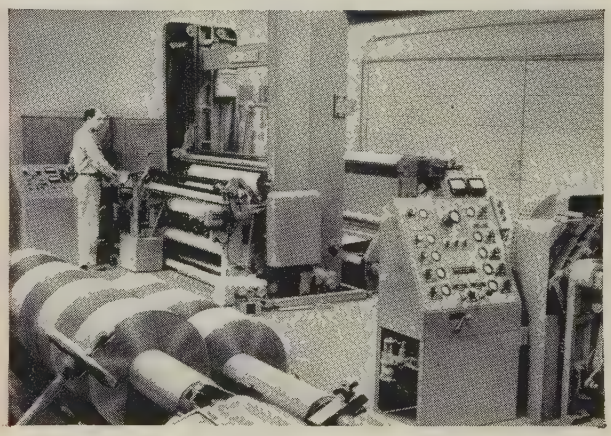
54 YEARS DEVOTED EXCLUSIVELY TO THE DESIGN AND

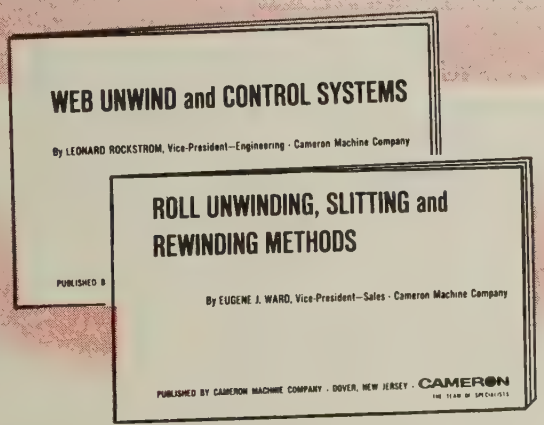
99% of your investment... get THE NEW ROLL now!

ONLY 1% of your production system is used to make your paper or board into rolls. The other 99% of your plant investment is already on the line when the web spins off the unwind, and that's a poor time to gamble on a makeshift roll production system. Why risk imperfect rolls which can result in damaged materials, lost time and dissatisfied customers? There is one sure way to provide maximum protection at the point where 99% of your investment is already at stake. You are protected all the way when you *control the roll from unwind to rewind on a completely integrated roll production system engineered by specialists.* The integrated system pays off in continuous, dependable, high volume production of clean-cut, straight-sided rolls of uniform, controlled density, ideal for handling and shipping, and perfect for feeding to modern, high speed printing and converting operations through faster, longer, trouble-free runs. That's *The New Roll!*

Protect that other 99% of your investment! Integrate your roll production system and get *The New Roll* now!

Recognizing the growing need for completely integrated automatic roll control, Cameron specialists have established a unique Testing and Development Department. Here is an assembly of roll winding, slitting, unwind and web control equipment, and auxiliary devices, which can be teamed in hundreds of combinations in order to provide the integrated system best suited for handling any material, in rolls of any size, at any speed. Whether you submit materials directly to this department for engineered test runs, or benefit indirectly from the pioneering experimental and development work carried on here, this Cameron service helps to protect the time and money you have invested in web materials of all kinds.




WEB UNWIND and CONTROL SYSTEMS
By LEONARD ROCKSTROM, Vice-President—Engineering · Cameron Machine Company
ROLL UNWINDING, SLITTING and REWINDING METHODS
By EUGENE J. WARD, Vice-President—Sales · Cameron Machine Company
PUBLISHED BY CAMERON MACHINE COMPANY · DOVER, NEW JERSEY · CAMERON

These two valuable books have been written by Cameron specialists to help you break through to new higher levels of profitable operation. Request, by title, your free copies.

FROM UNWIND TO REWIND Cameron roll production equipment is designed and manufactured by a *team of specialists* whose interest is devoted *exclusively* to roll production equipment and roll controls. That no comparable facilities are available elsewhere is evident in the list of Cameron products on the opposite page. Cameron offers you the complete background for a truly integrated roll production system. To stay ahead, call the Cameron team of specialists . . . get *The New Roll* now! AA 374

CAMERON MACHINE COMPANY, FRANKLIN ROAD, DOVER, N. J.
Canada: Cameron Machine Co. of Canada, Ltd., 15 Hatt Street, Dundas, Ontario
France: Batignolles-Chatillon, 5 Rue De Monttessuy, Paris (7e) France

MANUFACTURE OF SLITTING, ROLL WINDING, UNWIND AND WEB CONTROL EQUIPMENT.

They're both guns, but...

each is in a class by itself . . . like Wyandotte's PURECAL® O

A little bit of water won't do you any harm. But a little bit of lead? That's different! Still, there's no gun you can afford *not* to take seriously.

It's the same way with calcium carbonates. There are important differences . . . and it pays to give them careful consideration. Wyandotte PURECAL O is in a class by itself! Reason: It is precipitated by a special process which consistently yields agglomerate-free particles 0.15 micron in size, that are cubical in shape. Purity and whiteness are *exceptional.*

One of the many benefits this rigid standard of quality makes possible for you is a more fully automated operation. For example, slips made "off-formulation", by variations in other raw materials, are substantially reduced when PURECAL O is included in your coating formulations.

In the final analysis, however, PURECAL O must be proved in *your* formulation. So, for the practical test that will demonstrate its value . . . convince you of its advantages . . . write for samples and technical data, today. *Wyandotte Chemicals Corporation, Dept. 759-T, Wyandotte, Michigan. Offices in principal cities.*

Wyandotte CHEMICALS

MICHIGAN ALKALI DIVISION

PACING PROGRESS WITH CREATIVE CHEMISTRY

FULL STEAM AHEAD

ee the Cyanamid **MELOSTRENGTH*** Paper Exhibit at the TAPPI Convention

e you in the lobby of the Hotel Commodore, New York, February 22 through 25. We think you'll find the Cyanamid Exhibit teresting, fun—and believe it will help make your visit to New York more enjoyable. Features MELOSTRENGTH Resin—shows w it adds to the value of paper. Cyanamid, largest supplier of chemicals to the paper industry, invites you to see for yourself.

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CYANAMID

rademark

tmi for "good measure"

TMI MOTORIZED BENCH MICROMETERS

Automatic Operation: A gentle continuous raising and lowering of the upper anvil by means of a constant speed synchronous motor gives the same dwell time for each thickness.

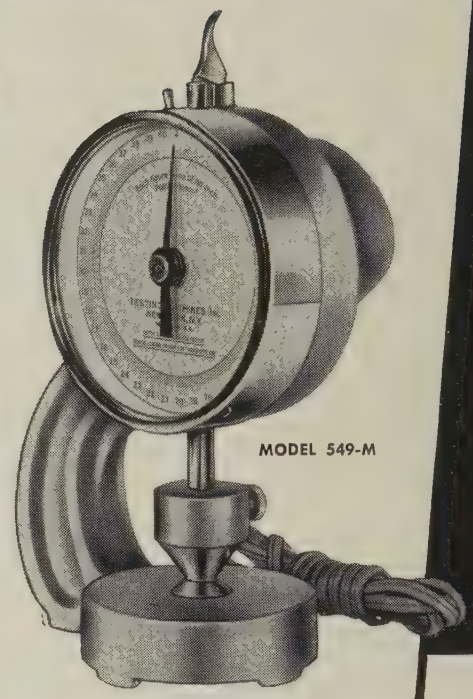
Uniform Dead Weight Load: Remains constant while the reading is taken.

Repetitive Readings Assured: No dropping of the anvil, as with hand operation. You get the same results from one operator to the next and between different departments or mills.

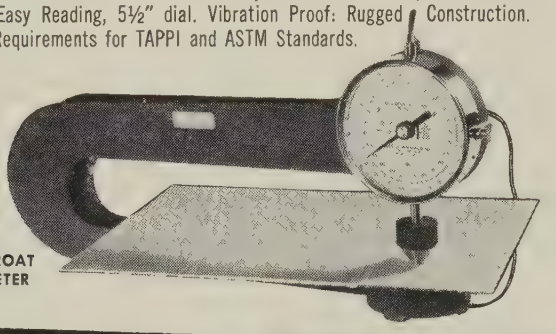
Increased Speed: The operator has both hands free to arrange samples and record results. Thin, filmy sheets are easily handled.

Other features are:

Lapped flat stainless steel anvils: Adjustable for exact parallelism. Large, Easy Reading, 5½" dial. Vibration Proof: Rugged Construction. Meets Requirements for TAPPI and ASTM Standards.



MODEL 549-M



DEEP THROAT MICROMETER

Something New!

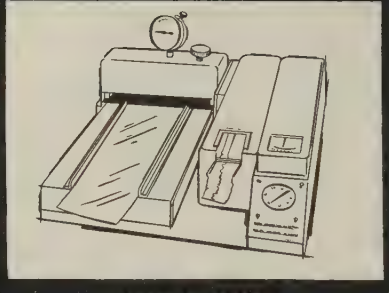
TMI MICRO-RECORDING PROFILER

Here is the very latest in automatic thickness measurement.

The best features of European and American design have been used to provide a rugged, practical instrument with great sensitivity.

The TMI Micro-Recording Profiler is an inexpensive, simple, and accurate recording profiler. Each graduation on the chart is twenty millionths of an inch!

Be sure to learn about this unit before you get any profiler. Write for complete details.



(reads to .00002")

Look to TMI for all of your other testing requirements, too!

THE TMI LINE INCLUDES MORE THAN 1079 TESTING MACHINES FOR BASIS WEIGHT — BURSTING — TEARING — FREENESS — SMOOTHNESS — PRINTABILITY — AND HUNDREDS OF OTHER PULP, SHEET AND CONTAINER TESTING MACHINES OF ALL TYPES.

Write for the 224 page TMI catalog and register of testing machines.
It is a worthwhile reference volume for your informational files.

tmi **TESTING MACHINES Inc.**

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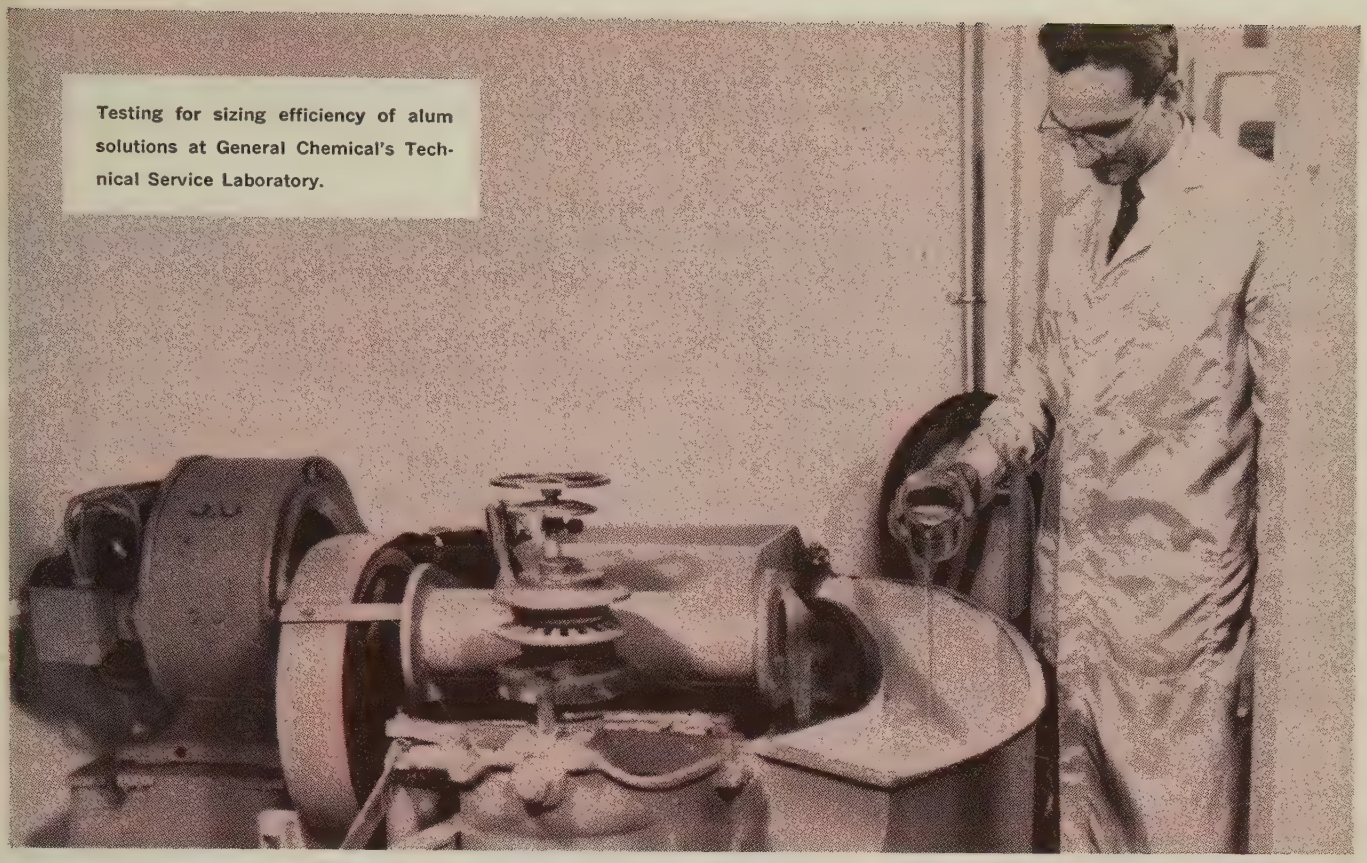
Manufacturers and Distributors of Fine Testing Machines



Testing for sizing efficiency of alum solutions at General Chemical's Technical Service Laboratory.

in GENERAL CHEMICAL ALUM
Another difference is TECHNICAL SERVICE

As the country's primary producer of alum, General Chemical is constantly helping customers solve technical problems involving the use of aluminum sulfate. Results? Improved efficiency and reduced operating costs for them.

Here are some of the services our Technical Service Department offers you:

- Supplying basic information helpful in planning design and installation of storing, pumping, metering and feeding facilities.
- Suggesting improvements to eliminate existing storing and handling problems.
- Providing chemists and operators with physical and chemical data necessary for the most effective use of alum.
- Assisting in laboratory tests and plant trials.
- Running check analyses in our own laboratories.

In the paper mill, our specialists advise on the most efficient use of aluminum sulfate for a particular mill's requirements. They can provide assistance on the important conversion from dry to liquid alum, and furnish guidance on the proper design of new installations and selection of materials to avoid handling or maintenance problems. In many instances, chemical problems arise in operations which are not necessarily related to alum. At such times, General's Technical Service continues to offer helpful advice and lend assistance whenever possible.

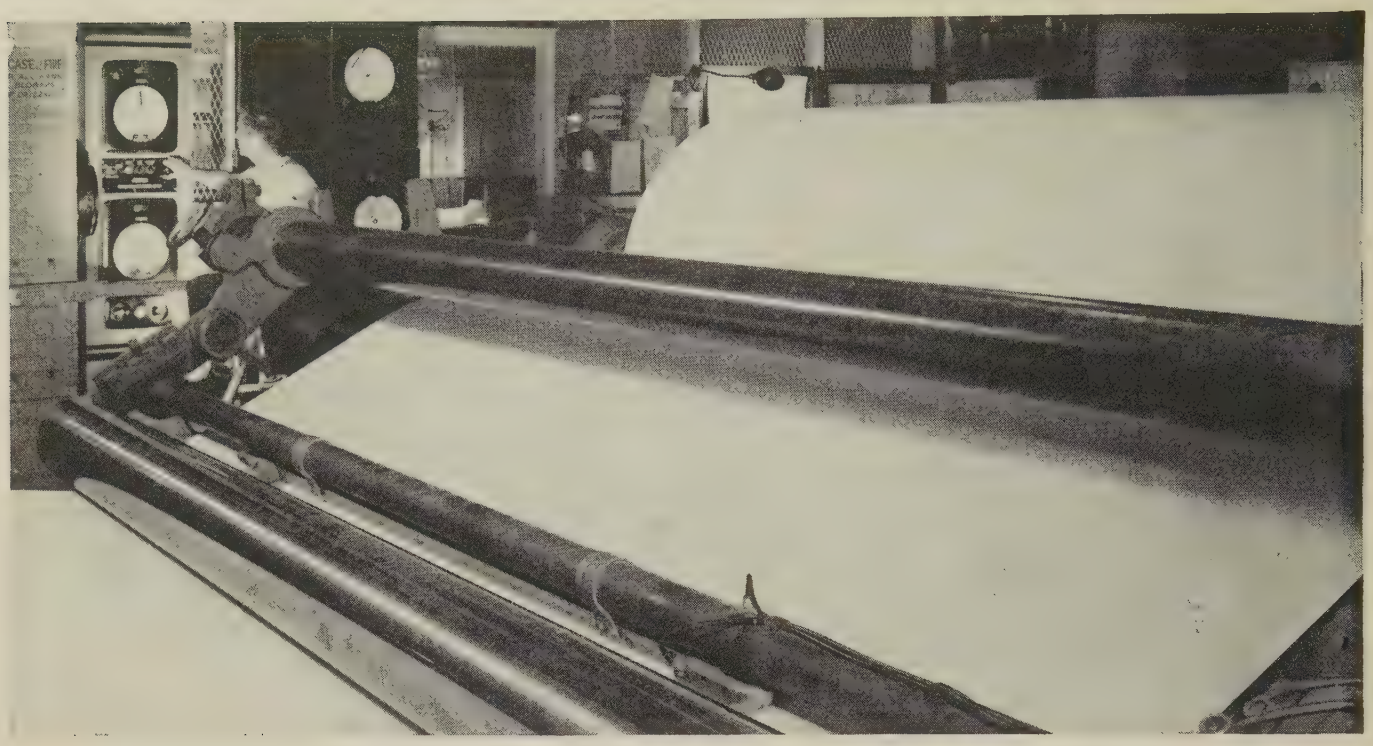
This kind of Technical Service is one of the reasons why General Chemical is a good company to do business with for *your* mill's alum requirements. We will welcome the opportunity to serve you.

Basic to America's Progress

Allied Chemical

GENERAL CHEMICAL DIVISION
40 Rector Street, New York 6, N. Y.

Paper-making processes stay



▲ MOISTURE CONTROL SYSTEM on #6 paper machine, Hammermill Paper Company, Erie, Pa. Unique Foxboro sensitive element measures 5 feet across paper — provides wide-span average measurement for fully effective machine control. Foxboro moisture control helps maintain paper uniformity — saves on steam as well.

▼ DIGESTER TEMPERATURES for Kraft Digester at Bowaters Southern Paper Corp., Calhoun, Tenn. are recorded on these Dynalog Electronic Instruments. To insure best possible digester circulation, Dynalogs record temperature measurements from both top and bottom of digesters. Second pen records continuous measurement of digester pressure. Other instruments on panel are Foxboro cam-set Steam Flow Controllers.

FOXBORO DYNALOG

REG. U.S. PAT. OFF.

on schedule . . .

with "no-maintenance" Foxboro Dynalog* Recorders

You'll find Foxboro Dynalog Electronic Instruments at work everywhere in a paper mill — measuring and controlling more than a dozen completely different paper processing variables.

Dynalogs give higher sustained measurement accuracy and greater freedom from maintenance than conventional potentiometers. They are free of drift — require no standardization, lubrication or alignment.

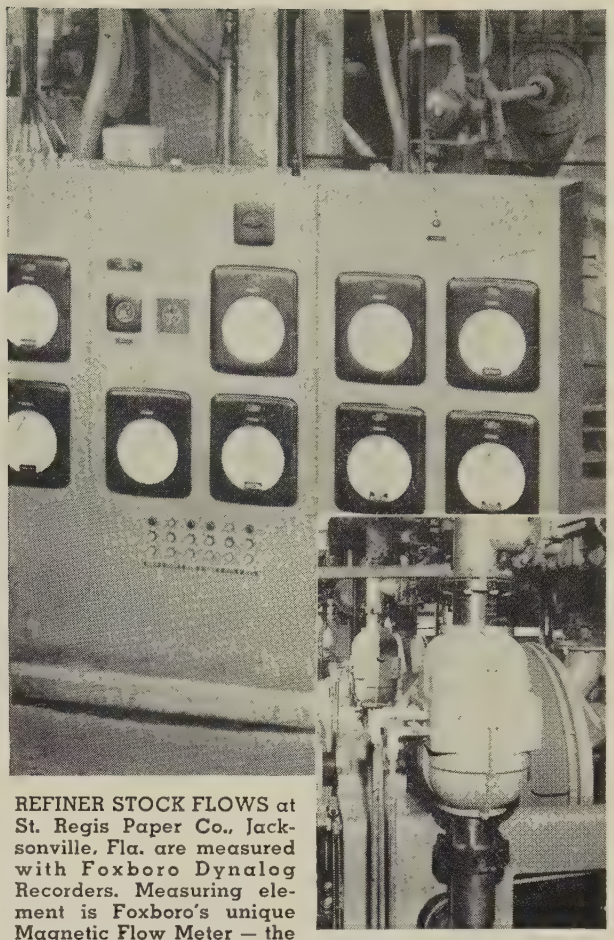
Dynalog design eliminates the slidewire and other moving parts found in conventional electronic recorders. Instead, a simple, variable radio-type capacitor with silent magnetic drive gives stepless continuous balancing. Smooth faster response without waste motion or wear.

For sustained high accuracy and freedom from maintenance, investigate sensitive Dynalog recorders — with fully-automatic pneumatic control action. They can be used for any electrical measurement . . . resistance, voltage, capacity, inductance. Write for Bulletin 20-10 — it gives all the details. **The Foxboro Company, 781 Neponset Ave., Foxboro, Mass.**

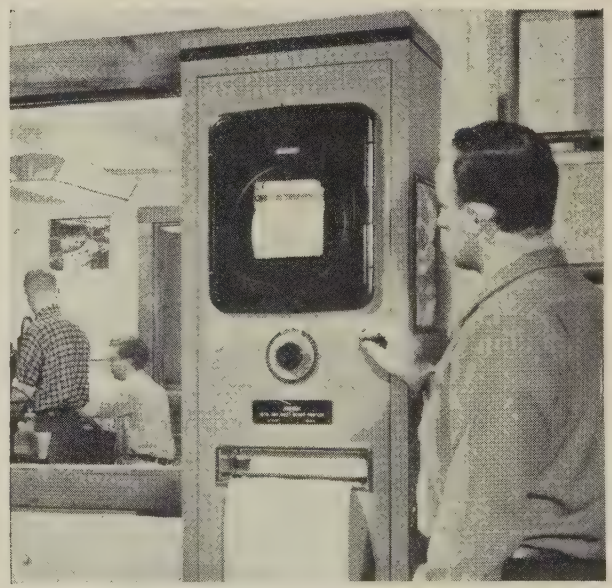
*Reg. U. S. Pat. Off.

Other paper-making processes using Foxboro Dynalogs

basis weight control
pH of machine furnish
evaporator boiling-point rise
conductivity for caustic and alum dilution; brown stock washer filtrate
ORP for pulp chlorination; bleach liquor
motor load for refiners, grinders, blow tank agitators
multi-record temperature measurements
density of lime-mud
. . . and many others



REFINER STOCK FLOWS at St. Regis Paper Co., Jacksonville, Fla. are measured with Foxboro Dynalog Recorders. Measuring element is Foxboro's unique Magnetic Flow Meter — the meter with no flow restrictions. Dynalog instruments also insure proper stock blending to paper machines.



SHEET WEIGHT PROFILER measures and records variations in the basis weight of full-width test samples of paper at American Box Board Co., Filer City, Michigan. Dynalog Strip Chart Recorder provides accurate deviation records all the way across the sheet.

ELECTRONIC INSTRUMENTS

C2®

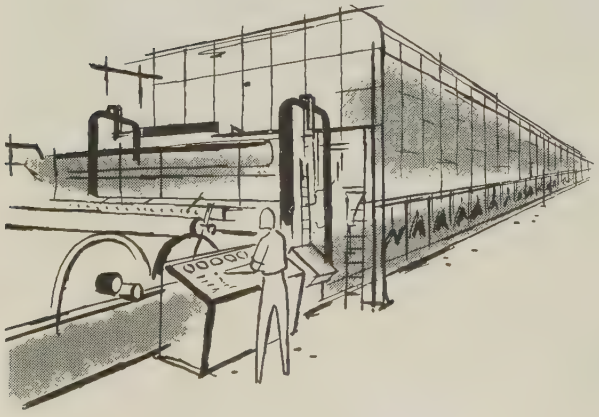
The New Slimicide

* non-toxic

* effective

* easy-to-use

* economical



A two year chronic toxicity study by the Medical College of Virginia indicates that C2 causes no toxicity problems within the recommended concentrations.

Up to one year experience in many mills demonstrates that C2 is an effective, low-cost slimicide for acidic white water systems. C2 treatment is free from taste and odor, and has no detrimental effects on dyes at the recommended use level. C2 does not cause foaming at the head box or darkening of the pulp.

C2, a sodium chlorite product, is readily soluble in water and is non-corrosive to equipment.

Average use level is 10 to 20 cents per ton of pulp. C2 is available in quantities ranging from one pound samples to 100 pound drums in truckloads and carloads. C2 also can be shipped as a 50% solution in tank cars or transports.

For assistance or further information, write the Sales Development Department, Baltimore 3, Md. Data sheet available upon request.

C2® is a trademark

6893

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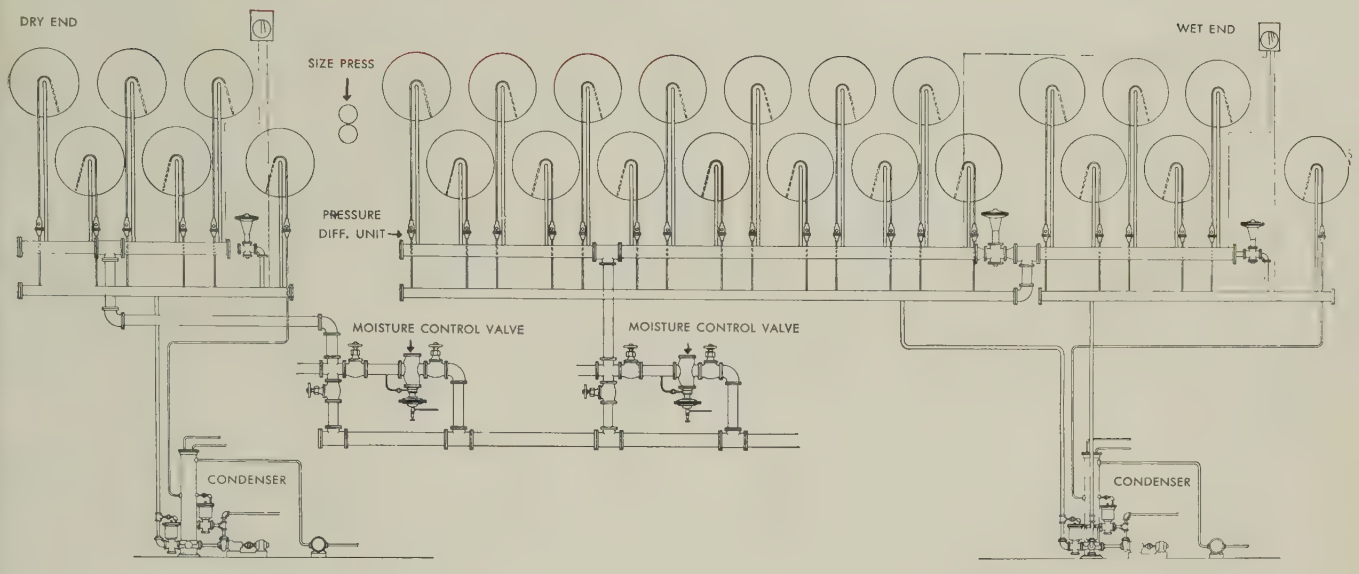
CHEMICAL CORPORATION
Chemicals Division • Baltimore 3, Md.

ALL Steamed Up OVER STEAM COSTS?



THEN THESE

FACTS WILL INTEREST YOU:

- The Appleton Dryer Drainage system dries paper at *lowest* possible steam cost.
- Steam is discharged from only the *first wet end dryer,* assuring maximum steam economy.
- Blow-through flash system uses no traps or flash tanks, provides natural descending heat curve toward wet end.
- Steam control valves *automatically* shut off during paper break, reopen when sheet is taken over machine preventing wet or over-dried paper.
- Exclusive, patented pressure differential units maintain proper differentials *under either pressure or vacuum conditions* guaranteeing removal of condensate and air.
- The system is versatile, now being used in mills running condenser tissue, towelling, glassine, writing papers, board and other grades.
- Installation is simple, in many instances existing piping may be used and installation made over weekend shut-down.
- *Complete details will be sent upon request. Please state if any special problems are involved. We will reply promptly, fully and without obligation.*

APPLETON MACHINE COMPANY
APPLETON, WISCONSIN

this laminated board was joined with SCRIPTITE* 54

*SCRIPTITE, LYTRON: Reg. U.S. Pat. O

Both hard and slack sized boards are today being laminated with Scriptite 54 adhesive. This water insoluble copolymer works efficiently in conventional laminating systems, producing laminated board that passes 48-hour and longer immersion periods with no delamination. Even when the laminate is forcibly separated, there's a complete fiber pull, no separation at the glue line. With 54, there's no need for heat or long storage curing periods —glue line water resistance sets immediately. For samples and new report, "Laminating Paperboard and Liner Board with Scriptite 54," write: Monsanto Chemical Company, Plastics Division, Room 739, Springfield 2, Mass.

Monsanto

The Monsanto line of paper resins also includes

SCRIPTITE 40 *urea type wet-strength resin.* **SCRIPTITE 33** *melamine wet-strength resi*
SCRIPTITE 55 *low viscosity resin for improved water resistance, wet and dry rub resist*
ance with easy handling. **SCRIPTITE 52** *in combination with formaldehyde, gives wate*
resistance to folding boxboard and jute liner. **SCRIPTITE 50** *unsurpassed printability*
improved surface characteristics on boxboard. **SCRIPTITE 45** *new thermosetting resin fo*
stabilization of paper. **LYTRON*** *water dispersal resin polymers for coatings.*

Underwraps...

Fine gift wrappings that say "we care" are made with Glidden Zopaque® Titanium Dioxide

On any occasion when gifts are given, quality wrappings made with Glidden Zopaque lend added appeal to each package.

Zopaque is ideal for formulation of finest paper products, providing maximum whiteness and brightness and a high degree of opacity. It also enhances the appearance of colored and printed stock.

Write now for complete details about the various grades of Glidden Zopaque Titanium Dioxide specially developed for beater addition and coatings.

QUALITY Glidden PRODUCTS

FINEST PIGMENTS FOR INDUSTRY

The Glidden Company
Chemicals—Pigments—Metals Division
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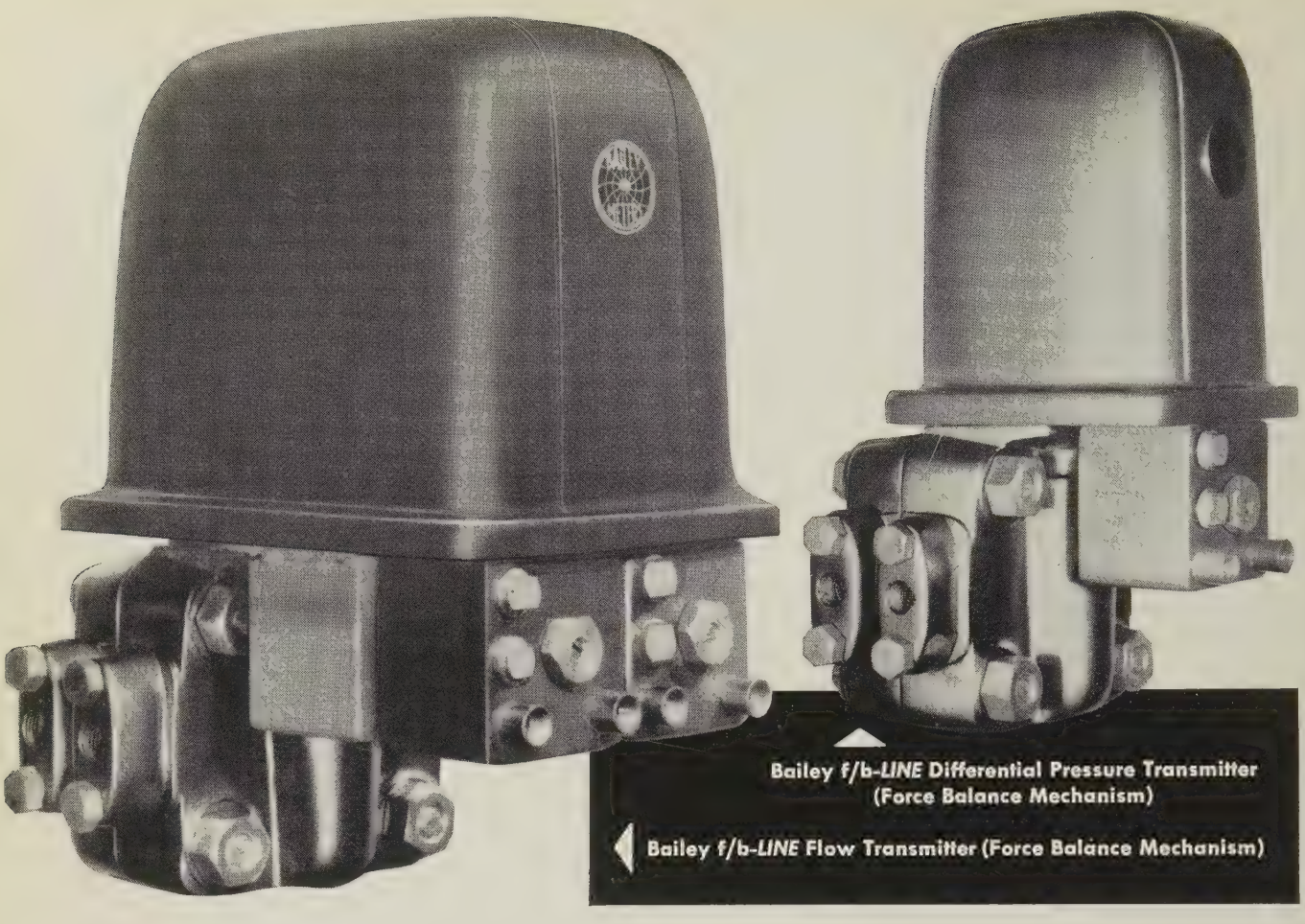

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The Effects of the Active Alkali Charge Upon Unbleached Pulp Yields and Quality in the Kraft Cooking of Southern Pinewood

E. D. CANN and W. B. ROBERSON

The data in two or three references pertinent to this topic are critically examined in an effort to obtain the maximum benefit from the published literature. Some experimental data on the cooking of southern pine wood with various active alkali charges, under mill cooking conditions, are presented and discussed from a practical point of view. Except for the screened yields remaining the same with the initial increase in the alkali charge rather than exhibiting an increase, the yield trends in the experimental data follow those reported in the literature. The permanganate numbers showed the expected decrease with an increase in active alkali charge. Pulp strengths increased slightly or at least remained the same with an increase in active alkali. The experimental data reported here indicate that the use of a moderate excess of active alkali, 18%, under the relatively mild cooking conditions employed led to optimum results, because good, or slightly improved, pulp strengths were obtained with little or no loss in yields. Although substantiating data have not, as yet, been acquired experience has shown that difficulties associated with pitch in pulps and with operations in the recovery unit can be avoided by the use of a moderate excess of active alkali.

Over the past four or five years it has been observed by the technical staff of Hudson Pulp and Paper Corporation that at least 12% more active alkali was used at the Palatka mill than that used by other comparable southern kraft mills. Where it is known that the use of excessive amounts of active alkali can lead to losses in pulp yields and quality, it seemed likely that these possible losses could be prevented by the use of less active alkali. Consequently, this investigation was initiated to determine the effects of decreasing and increasing the present active alkali charge under the cooking conditions employed at the Palatka mill.

In mill practice, kraft cooking is largely controlled by adjusting the alkali charge, whereas the other influential factors, such as the time-temperature schedule, sulfidity, etc., are more or less fixed in an established pulping operation. This importance of the chemical charge enhanced the need of determining the effects of a large alkali charge. It is true that the wood to liquor ratio can also be readily varied because the wood charge and the liquor volumes are normally measured for each cook by the operators. But, due to the insensitivity of this factor this ratio is not used to control the course of the cook. It is usually set at about 1:4 (on a weight basis) to permit efficient liquor circulation in the digester.

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The exceptionally high active alkali charge was favored by the production staff at the Palatka mill for the following reasons: (1) low rejects in order to limit the load on the pulp screening system, (2) easily refinable pulps to permit good strength development by the use of a limited power input, (3) light colored unbleached pulps, (4) improved recovery conditions due to the ease of evaporation and burning of the black liquors, and (5) good paper machine operation due to little or no trouble with problems associated with pitch. It is realized that the use of a large active alkali charge places an extra load on the recovery system, but an overload of 12% or slightly more should be readily handled by the use of some supplementary equipment. Throughout this work close attention was placed upon the advantages claimed to be associated with the use of a large active alkali charge.

A new pulping operation is generally initiated to meet certain production schedules and pulp quality requirements upon the basis of trade practices acquired from the experiences of the production staff. The cooking conditions may not be optimum, because the setting up of these conditions is often influenced by the whims and prejudices of the production staff and also to some extent by the limitation of the pulp mill equipment. In addition to the use of an unusually large alkali charge in the Palatka mill, the use of rather mild cooking conditions was quite apparent. These conditions consisted of steaming to a maximum temperature of 340°F. in 105 min. and then holding at this temperature for 45 min. The mildness of these conditions is evident when it is realized that a good number of the southern kraft mills steam to a maximum temperature of about 353°F. within 90 min. or less, and hold at these temperatures for about 30 min.

Kraft cooking involves the delignification of woods (or of other cellulosic materials) by the action of alkalies. Since this reaction is very complex, physically as well as chemically, due to the heterogeneous nature of wood, no attempt was made here to study the mechanics of this reaction in order to avoid unnecessary confusion and complications. Due to the endothermic nature of this reaction rather high temperatures are required to complete the kraft cook within the desired length of time. Since the rate and course of the pulping reaction depend upon the combined effects of the alkali charge and the heat introduced, the expected degrading effects of the large active alkali charge used at the Palatka mill will be minimized by the rather mild cooking conditions. Where these mild conditions

Table I.[a] Cooking Data

Cooking Conditions

Wood species—long leaf pine
Wood charge—4.0 lb.
Liquor concentration—50 g.p.l. (Total Chemicals)
Sulfidity—33%
Maximum temperature—170°C. (338°F.)
Time to maximum temperature—1½ hr.
Time at maximum temperature—1½ hr.
Indirect cooking

Chemical charge used (Based on O.D. wood)				Wood/liquor ratio, by weight	Yields, (%)			Chlorine no.
Active alkali, % as Na_2O	Total chemicals, % as NaOH & Na_2S	NaOH, % as NaOH	Na_2S, % as Na_2S		Screened	Screenings	Total	
11.7	15.0	10.0	5.0	1:3.0	8.3	50.0	58.3	13.6
13.1	16.8	11.2	5.6	1:3.5	45.2	7.5	52.7	10.3
13.7	17.5	11.7	5.8	1:3.6	47.4	4.4	51.8	6.1
14.7	18.8	12.5	6.3	1:3.7	48.3	2.4	50.7	8.1
15.6	20.0	13.3	6.7	1:4.0	48.4	0.7	49.1	5.6
17.6	22.5	15.0	7.5	1:4.5	47.1	0.3	47.4	4.9
19.5	25.0	16.7	8.3	1:5.0	46.3	0.1	46.4	4.3

[a] Data from Bray, M. W., Martin, J. S., and Schwartz, S. L., *Tech. Assoc. Papers*, 21: 441–446 (1938).

are satisfactory for meeting the present production schedules, they were employed in this study to show the effects of decreasing and increasing the chemical charge.

Only the conventional type of batch cooking involving the addition of the wood and cooking liquors at the start of the cook was used here because neither continuous nor injection cooking is practiced in the Palatka mill. Furthermore, attention was directed to unbleached pulps with no consideration being given to a bleaching operation.

In this investigation a review of the trade literature was carried out to secure all available information on the subject relative to pulp yields and papermaking qualities, and a background upon which to base some experimental pulping under conditions very similar to those practiced in the mill. Some of the more pertinent references are cited here. Data from the experimental cooks are presented to show the effects of different active alkali charges upon pulp yields and quality under mill conditions. Upon the basis of the data presented conclusions are drawn relative to what might be expected from increasing and decreasing the active alkali charges in the mill.

BACKGROUND

In the survey of the trade literature to secure information on this particular topic attention was directed to the effects upon the yields and the papermaking properties of unbleached pulps. The scientific literature was not covered in this case because no attempt was made here to include a detailed study of the mechanics of the kraft pulping reaction for the following two reasons: first, the present controversial nature of this subject would likely lead to confusion, and second, most of the fundamental data on the mechanics of the reaction does not lend itself to immediate application. In a more detailed study of this topic the scientific data in literature would provide a most valuable background, because such fundamental information could eventually lead to important contributions to the kraft pulping industry. The main purpose of this work was to obtain information that would find direct application to our pulping operation.

A group of papers published by workers at the U. S. Forest Products Laboratory proved of considerable interest, for which reason these papers are briefly discussed here.

Bray, Martin, and Schwartz (*3*) reported some data on the pulping of silver firwood to show the effects of alkali concentration upon pulp yields and quality. Some of these data were examined in detail to arrive at the following conclusions:

Both the total and accepted yields dropped sharply when the chemical concentration was increased from 30 to 40 g.p.l. but decreased only gradually with further increases in chemical concentration. These results showed little direct relationship between pulp properties and alkali concentration, but the pulp cooked with 50 g. of total chemicals per liter gave the highest burst and tensile development, and was more readily beaten than the pulps cooked with less or greater alkali concentrations. The chemical concentration was varied in this work by dilution with water. This technique introduced a second variable, namely, the wood to liquor ratio, which is of unknown importance. Due to the existence of this second variable

Table II.[a] Strength Values—Pebble Mill Test

Active alkali charge, (%)	Beating times: Freeness (Schopper ml.) 0	20	40	50	60	70	80	100	Burst factor (pt./lb./ream) 0	20	40	50	60	70	80	100
13.0	...	882	857	...	807	...	697	550	...	0.67	0.95	...	1.08	...	1.20	1.23
13.6	900	885	862	...	810	...	715	562	...	0.71	0.97	...	1.10	...	1.22	1.24
14.6	905	880	865	...	830	...	767	667	...	0.66	0.99	...	1.11	...	1.17	1.26
15.5	895	870	797	720	620	460	360	...	...	0.84	1.08	1.17	1.21	...	1.29	...
17.4	895	867	795	...	605	...	390	...	...	0.86	1.13	...	1.22	...	1.31	...
19.4	890	865	790	...	615	...	410	...	...	0.92	1.22	...	1.34	...	1.41	...
	Tear Factor (pt./lb./ream)								Tensile Strength (lb./in.)							
13.0	...	2.60	2.35	...	2 30	...	2.10	1.95	...	2625	4097	...	5465	...	6970	7345
13.6	...	2.40	2.30	...	2.20	...	2.05	2.00	...	2702	4395	...	5855	...	6055	6785
14.6	...	2.70	2.55	...	2.50	...	2.40	2.40	...	2556	4170	...	5125	...	5260	6985
15.5	...	2.40	2.30	2.15	2.15	...	2.00	...	...	4000	5195	6000	6790	6875	7720	...
17.4	...	2.55	2.35	...	2.25	...	2.20	...	...	3760	5087	...	6595	...	7115	...
19.4	...	2.40	2.35	...	2.15	...	1.95	...	...	4000	5190	...	6855	...	7465	...

[a] Data from Bray, M. W., Martin, J. S., and Schwartz, S. L., *Tech. Assoc. Papers*. 21: 441–446 (1938).

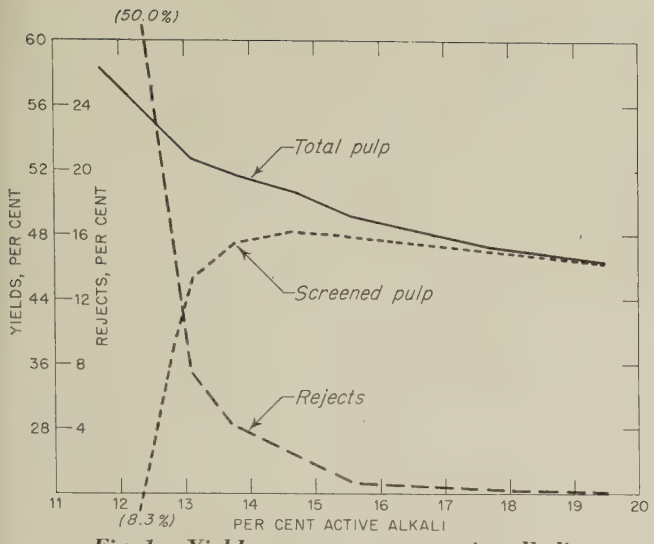

Fig. 1. Yields versus per cent active alkali

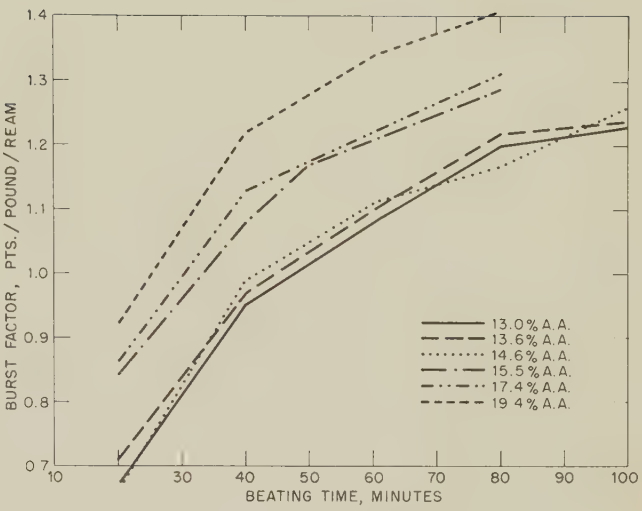

Fig. 3. Burst factor versus beating time

and the use of some impractical cooking conditions, the trends indicated in these data are of doubtful value in respect to application to mill practice.

Another paper by the same authors (4) on the kraft pulping of longleaf pine was found of special interest. In order to put this experimental data on a practical basis the chemical charges employed in this work were calculated as per cent active alkali based on dry wood. Some of these data are reported in Tables I and II, and plotted in Figs. 1, 2, 3, 4, and 5 to illustrate some of the pertinent trends.

Figure 1 shows that the screened yields increased sharply as the per cent active alkali was increased from 11.7 to 14.7%, after which these yields gradually decreased with further increases in active alkali. Since the total yields continually decreased, it follows that up to the breaking point at 14.7% active alkali the rejects are converted to screened pulp at a much greater rate than the pulp is dissolved, and that beyond this point the screened pulp is cooked out almost as rapidly as the rejects are pulped. As a result of these associated effects upon yields the rejects are sharply reduced up to the breaking point and then but slightly decreased with the larger alkali charges.

Figure 2 shows that the pulps on either side of the breaking point vary widely relative to their beating characteristics, in that the pulps cooked with the larger amounts of active alkali beat more rapidly than those cooked with lower active alkali charges. Figure 3 shows a close relationship between active alkali charge and burst strengths which is rather contrary to the data obtained with the silver firwood. Figure 4 illustrates a general but somewhat irregular relationship between tensile strengths and the active alkali charge. Figure 5 exhibits little or no relationship between tear factors and the active alkali charge.

In the work with silver fir it was found that an initial chemical concentration of 50 g. of total chemicals per liter (equivalent to 15.6% active alkali as Na_2O when based on moisture-free wood and a 1:4 w/l) gave optimum results in respect to pulp yields and quality. Upon the basis of this finding this chemical concentration was maintained in the experimental work with long leaf pine. As the result of maintaining this constant active alkali concentration, the wood to liquor ratio was varied along with the alkali charge. The simultaneous introduction of these two variables makes the direct application of these results somewhat questionable, but it is felt that some of the general trends gave useful indications.

The general disagreement between the trends of the pulping data obtained with the two different woods,

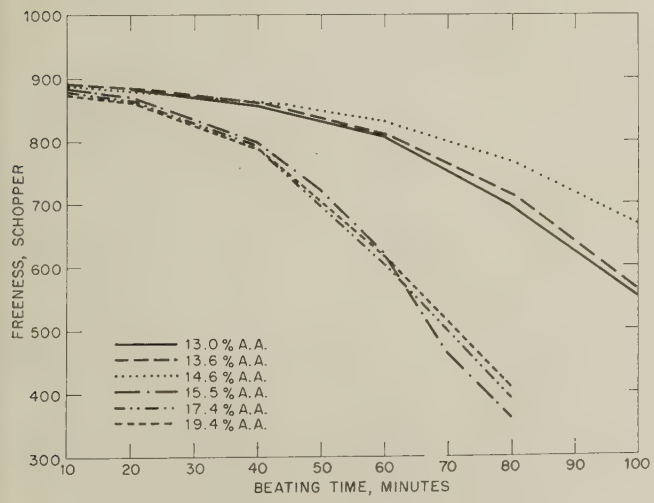

Fig. 2. Freeness versus beating time

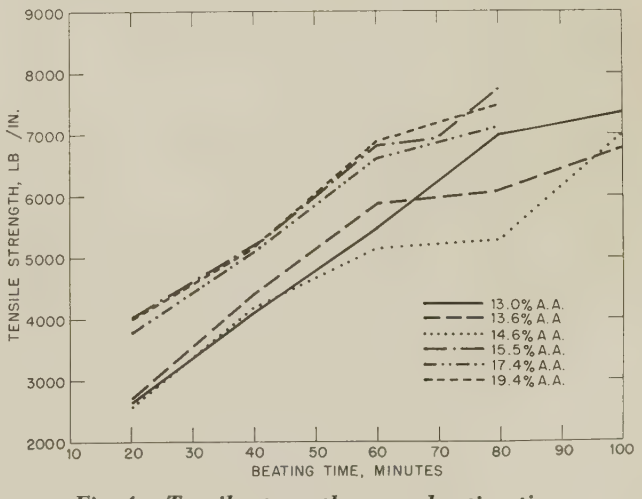

Fig. 4. Tensile strength versus beating time

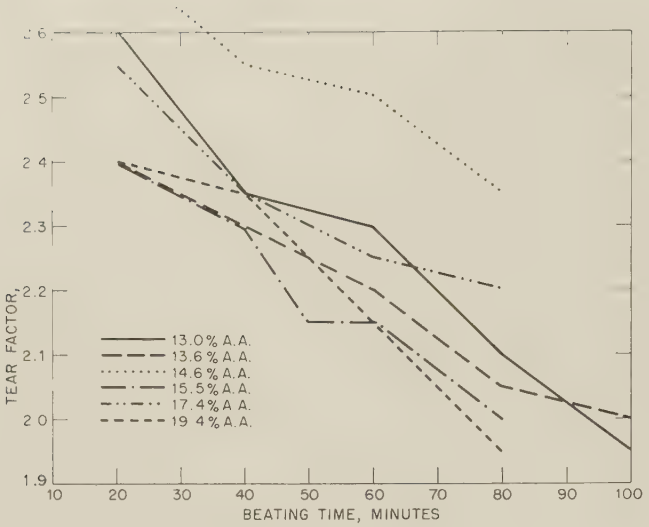

Fig. 5. Tear factor versus beating time

namely, silver fir and longleaf pine, implies that these woods respond differently in the kraft cook.

Martin and Bray (*7*) repeated the work on long leaf pine with Douglas-fir, which gave similar trends of the same magnitude. The comparative work on these two woods led to the conclusion that "the systematic variation of the chemical wood ratio in the sulfate process can be used as a measure of the relative ease of fiberization among species." A comparison of the data similarly obtained on the two woods indicated that along with several differences Douglas-fir fiberizes slightly more readily than does longleaf pine.

Schwartz and Bray (*8*) conducted a rather thorough study of this topic. These authors reported a considerable amount of basic data in their article. But, where the conditions used varied widely from those employed in mill practice, these data have little practical application. For this reason this reference is merely mentioned here.

Bishop (*1*) explained how pulp strengths were improved by varying the pulping procedure under mill conditions at the Southland Paper Mills. Clues for directing this work were obtained by comparing the cooking conditions used at the various southern kraft mills and also the strength of pulps produced at these mills. It was concluded from this comparison that a high active alkali concentration was conducive to the production of high strength kraft pulps from southern pine woods. From the initial concentration of active alkali reported to have been required to effect an improvement in pulp strength, it was estimated that about 18% active alkali (based on dry wood) was employed at Southland. Where this is the active alkali charge used at Palatka, it follows that in this case the use of at least 12% more active alkali than is used by the average southern kraft mill will lead to improved pulp strengths. Unfortunately, neither the actual strength improvements attained nor the time-temperature cooking schedule were reported in this paper.

EXPERIMENTAL

For the experimental phase of this work a large quantity of regular pine chips was secured from the mill wood room on Jan. 16, 1958. The wood being debarked and chipped at the time came from recently arrived railcars and was estimated to consist of about 76% slash pine with loblolly and shortleaf pine making up the balance. After careful hand sorting of the chips to remove knots and the abnormal types of chips, cooking batches of some 60 lb. (fresh weight) were weighed and stored in polyethylene coated multiwall bags. Several moisture samples were taken to determine the moisture content of the fresh chips, which was used to calculate the moisture-free weight of wood employed in each cook. The mill white liquor with a sulfidity of 27%, a causticity of 80%, and an active alkali content of 5.94 lb per cu. ft. used in the experimental cooks was analyzed for total active alkali by the mill method. This method simply consisted of first precipitating the carbonates as barium carbonate and then titrating with a standard acid to the methyl orange end point. Mill water was used in place of black liquor to maintain a wood to liquor ratio of 1:4 in all cooks. The waste or black liquors from the

Table III. Cooking Data on Regular Southern Pine Wood

(Date of Wood Sample—Jan. 16, 1958)

Cooking Conditions

Wood species —slach 70%, shortleaf 15%, and loblolly 15%
Wood charge—32. lb. (moisture-free)
Wood/liquor ratio—1:4
Sulfidity—28%
Maximum temperature—341°F.
Maximum pressure—105 p.s.i.
Time to maximum temperature—105 min.
Time at maximum temperature—45 min.
Total cooking time—150 min.
Indirect cooking

Cook no.	Active alkali, % as Na_2O		Yield			Miscellaneous data		
	Based on moisture-free wood	Based on liquor	Accepted, %	Rejects, %	Total, %	$KMnO_4$ no. (TAPPI)	Res. alkali (as Na_2O) % by volume	Chemicals used, %
129	16.0	4.0	46.8	2.0	48.8	32.0	1.92	67.0
130	16.0	4.0	45.4	1.7	47.1	31.5	1.61	70.0
133	16.0	4.0	46.1	1.5	47.6	31.8	1.59	71.0
		Average	46.1	1.7	47.8	31.8	1.71	69.0
119	18.0	4.5	46.8	2.3	49.1	28.0	2.14	56.7
120	18.0	4.5	45.3	2.0	47.3	26.9	2.24	54.7
126	18.0	4.5	46.7	1.3	48.0	26.2	2.13	56.8
		Average	46.3	1.9	48.2	27.0	2.17	56.1
121	20.0	5.0	44.0	1.9	45.9	21.8	2.38	56.8
122	20.0	5.0	44.7	1.2	45.9	21.3	2.40	56.4
127	20.0	5.0	44.0	0.9	44.9	21.6	2.38	56.8
		Average	44.2	1.3	45.5	21.6	2.39	56.7
123	22.0	5.5	41.1	0.8	41.9	20.0	2.84	53.0
124	22.0	5.5	41.4	0.8	42.2	20.3	2.80	54.0
128	22.0	5.5	41.3	0.6	41.9	19.5	2.78	53.8
		Average	41.3	0.7	42.0	19.9	2.81	53.6

Table IV. Strength Data—TAPPI Standard Beater Tests at Various Beating Times (Unbleached Pulps)

Cook no.	Active alkali, %	Freeness 0	Freeness 15	Freeness 30	Freeness 45	Freeness 60	Density 0	Density 15	Density 30	Density 45	Density 60	Burst factor 0	Burst factor 15	Burst factor 30	Burst factor 45	Burst factor 60	Tear factor 0	Tear factor 15	Tear factor 30	Tear factor 45	Tear factor 60	Tensile, lb./in. 0	Tensile, lb./in. 15	Tensile, lb./in. 30	Tensile, lb./in. 45	Tensile, lb./in. 60
129	16	730	680	563	359	177	0.32	0.47	0.54	0.58	0.63	13.4	32.4	67.2	74.8	78.2	278	260	202	171	149	10.3	22.5	29.4	31.8	33.0
130		724	677	542	328	146	0.33	0.49	0.55	0.60	0.63	16.0	45.8	65.5	81.4	78.3	258	224	165	154	151	11.9	23.9	30.4	32.0	35.4
133		711	647	461	228	101	0.36	0.52	0.58	0.62	0.67	19.4	54.2	71.7	78.6	77.6	276	199	167	145	133	12.6	25.4	32.4	33.9	34.6
	Average	722	668	522	305	141	0.34	0.49	0.56	0.60	0.64	16.3	44.1	68.1	78.3	78.0	271	228	178	157	144	11.6	23.9	30.7	32.6	34.3
119	18	748	708	598	365	175	0.32	0.49	0.53	0.59	0.64	13.9	48.4	68.8	78.4	82.1	228	211	188	142	138	10.3	23.6	29.1	30.7	34.0
120		731	705	538	306	135	0.32	0.50	0.56	0.61	0.65	16.0	50.8	72.7	81.5	79.3	300	240	192	147	138	11.0	24.6	30.4	39.6	41.4
126		730	679	548	345	180	0.31	0.49	0.56	0.59	0.63	15.1	50.1	69.0	77.4	85.8	297	239	187	171	158	10.6	22.1	30.1	33.9	34.9
	Average	736	697	561	339	163	0.32	0.49	0.55	0.60	0.64	15.0	49.8	70.2	79.1	82.4	275	230	189	153	145	10.6	23.4	29.9	34.7	36.7
121	20	727	666	520	304	148	0.37	0.52	0.59	0.63	0.67	19.2	58.0	73.7	79.3	79.0	336	216	176	154	144	13.3	28.5	33.0	34.2	36.5
122		716	645	458	236	117	0.42	0.55	0.59	0.64	0.68	24.0	63.0	76.8	78.0	80.8	327	200	166	150	134	14.8	27.4	32.8	35.8	35.0
127		706	625	450	238	85	0.36	0.54	0.59	0.67	0.71	15.6	55.8	72.0	78.7	80.2	306	232	185	148	139	9.6	25.9	30.9	34.2	34.3
	Average	716	645	476	259	117	0.38	0.54	0.59	0.65	0.69	19.6	58.9	74.2	78.7	80.0	323	216	176	151	139	12.6	27.3	32.2	34.7	35.3
123	22	726	650	466	239	96	0.35	0.54	0.59	0.64	0.68	16.1	55.7	72.0	76.7	80.7	340	210	166	149	128	15.1	27.6	29.4	35.0	35.2
124		721	646	480	271	105	0.35	0.52	0.59	0.63	0.67	18.4	57.1	72.4	75.5	80.5	306	235	174	161	142	14.0	27.5	33.0	35.1	34.5
128		707	628	424	207	100	0.37	0.55	0.57	0.63	0.67	14.2	56.5	73.2	79.4	79.7	283	222	182	167	145	11.1	26.2	31.1	34.2	35.7
	Average	718	641	457	239	99	0.36	0.54	0.58	0.63	0.67	16.2	56.5	72.5	77.2	80.3	311	229	174	159	138	13.4	27.1	31.2	34.8	35.1

cooks were analyzed for residual alkali as was the active alkali determined in the white liquor except methyl purple was used in place of methyl orange to give a more distinct end point.

By studying the operating reports and discussing the mill cooking procedures with the production personnel the mill cooking conditions were carefully obtained for use in this work. Briefly these cooking conditions consisted of steaming to the maximum temperature of 341°F. in 105 min. and holding at this maximum temperature for 45 min. A 1:4 wood to liquor ratio (on a weight basis) was maintained in all cooks. In order to approximate mill conditions the digester contents were first heated from ambient temperatures to the usual mill temperature of 170°F. in 5 min. at the start of the cook.

Since from 16 to 22% of active alkali (as Na_2O based on wood) is used in mill practice in the production of unbleached pulps for wrapping and bag papers, this range was covered in increments of 2%. In order to minimize experimental errors triplicate cooks were carried out with the following alkali charges; 16, 18, 20, and 22%. Where 18% is the active alkali charge being used at the Palatka mill, the data from these experimental cooks should show what could be expected from increasing and decreasing the present active alkali charge.

A stainless steel digester equipped with a circulatory system was employed in these experimental cooks. The chips and measured volumes of white liquor and water were introduced at ambient temperatures, and the top was securely bolted down. Steaming was done indirectly by use of a high capacity heat exchanger, through which the liquor was pumped from the bottom to the top of the digester by use of a Chempump. The cooks were blown at pressure into a cyclone from which the digester contents dropped into an open wash tank. The stock was collected on a sheet of broadcloth which was stretched across the wash tank and supported by a raised wire screen in the bottom of this tank. After washing the stock free of black liquor by using mill water, it was screened through a laboratory flat screen containing a 16-cut plate and then pumped to a 500-gal. tank. All of the equipment which came in contact with the stock was made of type 316 stainless steel.

The yield of screened stock was determined in the usual way by diluting to a fixed volume in the 500-gal. tank and then determining the consistency of this stock. The screened rejects were determined directly by drying and weighing the entire mass. All yield values were calculated on the basis of the moisture free wood. Pulp samples for permanganate numbers, beater tests, etc., were drawn off the yield tank, thickened in a centrifuge and stored in polyethylene bags. The pulps were preserved in storage by placing paper towels soaked with formaldehyde in the polyethylene bags.

RESULTS

The data obtained from this series of experimental cooks are reported in Table III, while the Valley beater test results obtained on these pulps by the use of TAPPI procedures are given in Table IV.

In order to illustrate the differences and trends exhibited by this experimental data, the average yield values are plotted against the active alkali charge in Fig. 6. The freeness and tensile strength values are plotted against beating times in Fig. 7, while the burst and tear factors, and sheet densities are similarly treated in Fig. 8.

DISCUSSION OF RESULTS

In Fig. 6 it is shown that the total and accepted (screened)

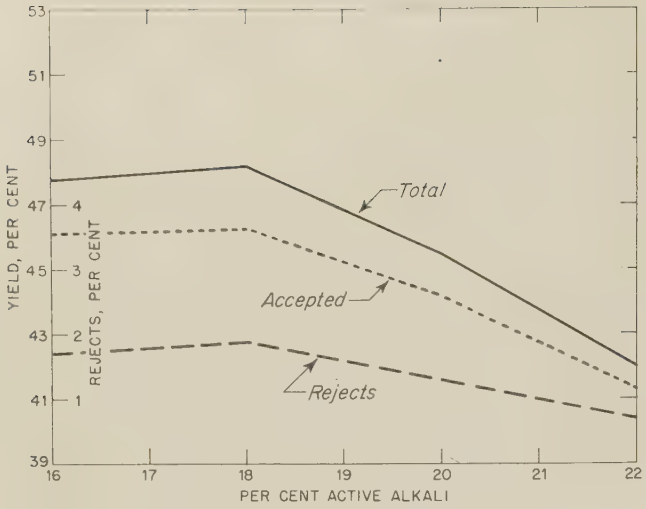

Fig. 6. Yields versus chemical charge (% A.A.)

yields and rejects did not increase upon decreasing the active alkali charge from 18 to 16%. From the work of Bray *et al.* (*4*) the total yields would be expected to increase sharply in this range as a result of a marked rise in rejects with a simultaneous decrease in accepted yields. This unexpected trend of results from decreasing the active alkali charge in the low range is likely caused by the use of mild cooking conditions. These data indicate that higher yields would not be realized by decreasing the present charge from the usual 18% under these cooking conditions.

Further increases in the active alkali charge effected a decrease of both total and accepted yields with the former showing a slightly sharper drop to cause a simultaneous but slight drop in rejects. It follows from these yield results that under the cooking conditions employed 18% active alkali is the optimum charge. From Table III it will be noticed that the permanganate numbers of the pulps continually decreased with an increase in active alkali charge, which is the expected trend in that the rate of delignification is accelerated by increasing the active alkali. Since the slopes of the freeness versus beating time curves in Fig. 7 are similar, it follows that these pulps possessed about the same beatability. This result differs rather widely from that reported by Martin and Bray (*4*). The tensile strength curves of this figure show that with

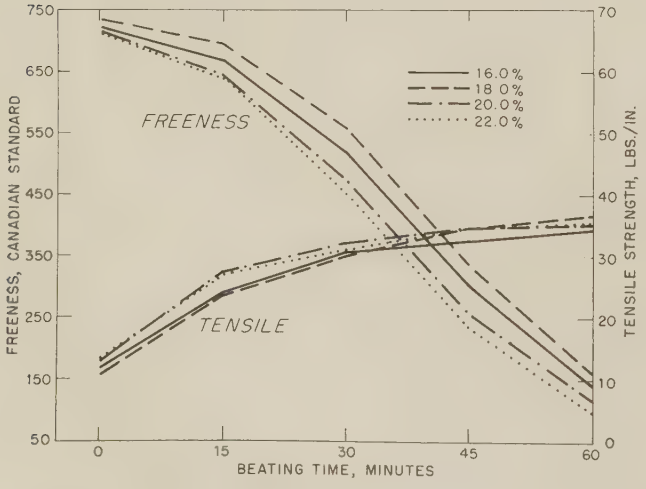

Fig. 7. Freeness and tensile versus beating time

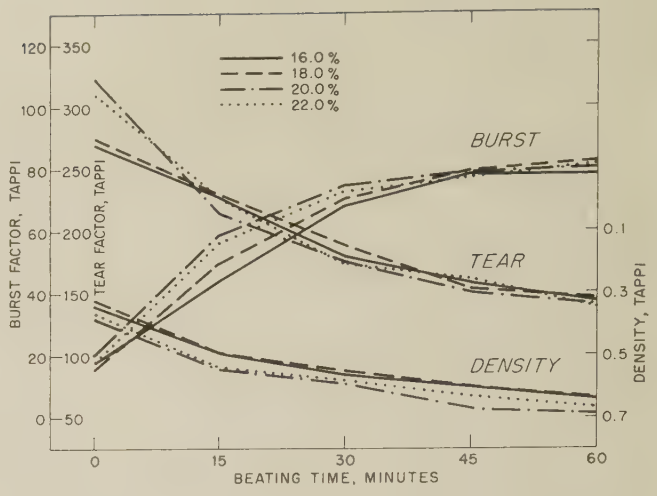

Fig. 8. Burst, tear factors, and density versus beating time

the usual amount of beating used in the mill, represented here by 23 to 30 min. beating time, this strength property is increased about 10 to 15% by increasing the active alkali to 20 to 22%.

In Fig. 8 it is indicated that with 23 or 30 min. beating time the burst factor would be decreased some 5 to 7.5% by decreasing the active alkali from 18 to 16%, while an increase in the charge from 18 to 20 or 22% would cause a 10% increase in burst factors. Apparently, these differences in burst strength disappeared when the freeness was lowered down to around 300 ml. by beating for some 45 min. The tear factors in Fig. 8 show practically no relationship with the alkali charge. This figure also shows that the use of the larger active alkali charges led to higher sheet densities. Unfortunately, the significance of these trends in respect to the actual papermaking qualities of these pulps is difficult to predict. However, it is believed that they are not appreciable. In any case it is evident that where the larger alkali charge showed a noticeable increase in burst and tensile strengths, with no clear-cut loss in tear strength, it can be concluded that the use of 18% active alkali (or 688 lb. per ton of pulp) will not adversely affect pulp strength under the cooking conditions employed here.

To summarize the pertinent points exhibited by these data it is apparent that the 18% active alkali

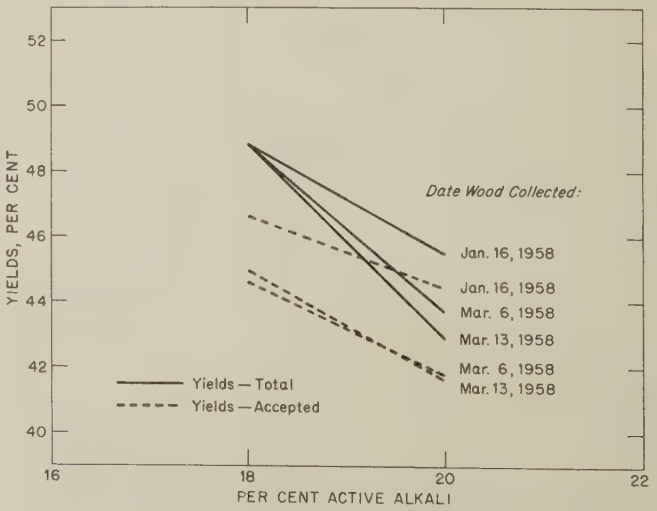

Fig. 9. Yields versus chemical charge (% A.A.)

Table V. Cooking Data on Regular Southern Pine Woods

Cooking Conditions

Wood species—slash 70%, shortleaf 15%, loblolly 15%
Wood charge (moisture-free)—3.7 lb. (March 6, 1958 sample)
3.2 lb. (March 13, 1958 sample)
Wood/liquor ratio—1:4
Sulfidity—28%
Maximum temperature—341°F.
Maximum pressure—105 p.s.i.
Time to maximum temperature—105 min.
Time at maximum temp.—45 min.
Total cooking time—150 min.
Indirect cooking

Cook no.	Active alkali, % as Na_2O		Yield			Miscellaneous data		
	Based on moisture-free wood	Based on liquor	Accepted, %	Rejects, %	Total, %	$KMnO_4$ no. (TAPPI)	Residual alkali (as Na_2O) % by volume	Chemicals used, %
			Date of Wood Sample—March 6, 1958					
134	18.0	4.5	43.8	3.8	47.2	28.9	2.24	54.9
135	18.0	4.5	45 3	3 0	48 7	28.8	2.20	55.6
		Average	44.6	3.4	48.0	28.8	2.22	55.2
136	20.0	5.0	42.0	2.7	44.7	26.1	3.38	56.8
137	20.0	5.0	41.4	1.4	42.8	25.8	2.40	56.4
		Average	41.7	2.0	43.7	25.9	2.39	56.6
			Date of Wood Sample—March 13, 1958					
138	18.0	4.5	45.3	3.4	48.7	27.8	1.91	63.4
139	18.0	4.5	44.5	3.2	47.7	27.4	1.84	63.0
		Average	44.9	3.3	48.2	27.6	1.87	63.2
140	20.0	5.0	41.0	1.1	42.1	21.4	2.47	55.0
141	20.0	5.0	42.2	1.6	43.8	21.2	2.46	55.2
		Average	41.6	1.3	42.9	21.3	2.46	55.1

normally used in the mill gave relatively good yields and good pulp quality under the cooking conditions employed here. Also, it was shown that the use of higher active alkali charges would tend to improve pulp quality with a simultaneous loss in yield, while a decrease in active alkali charge would prove somewhat detrimental to pulp quality with no appreciable increase in yields.

In the course of another pulping project two samples of pine chips were taken from the mill woodroom during March of 1958 and cooked with 18 and 20% active alkali under the regular mill cooking conditions. In order to supplement the earlier data, the cooking results obtained on these two wood samples are reported in Table V, while the beater test values determined on these particular pulps are given in Table VI. The yield values secured on the three different pinewood samples with 18 and 20% active alkali are plotted against the per cent active alkali in Fig. 9. The freeness and tensile strength values of Table VI are plotted against beating times in Fig. 10, while the burst and tear factors and sheet densities of this table are similarly plotted in Fig. 11.

The only similarity shown by the three wood samples in Fig. 9 is that all yield values dropped with an increase in alkali charge, but neither the magnitude of the yields nor the extent of this yield drop were alike with all the woods. Since the two samples taken in March more closely resembled each other in this respect, it would appear that the differences noted here could be due to a seasonal effect.

From Fig. 10 it will be noticed that with some minor exceptions the pulps produced from the March wood samples exhibited about the same beatability. Where the strength results in Fig. 10 and 11 do not exhibit the same trends in respect to the alkali charge with the two March wood samples, nothing conclusive can be drawn from these results other than that differences in wood samples seemed to influence the effects obtained from increasing the active alkali charge.

It is indicated here that different woods will respond differently with changes in active alkali charge, which in this case seems to be due to seasonal differences or possibly to minor differences in species or site. Since these differences are quite noticeable there is no wonder that different results have been reported in literature with widely different woods and with rather different pulping techniques. The full significance of these observations should be ascertained by more extensive work along these lines.

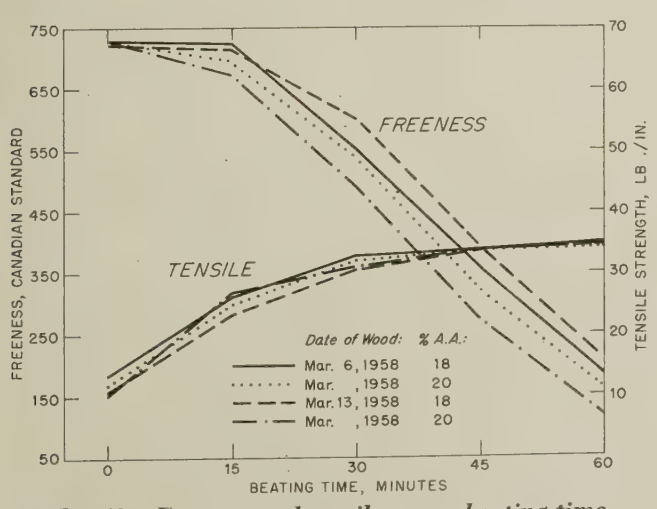

Fig. 10. Freeness and tensile versus beating time

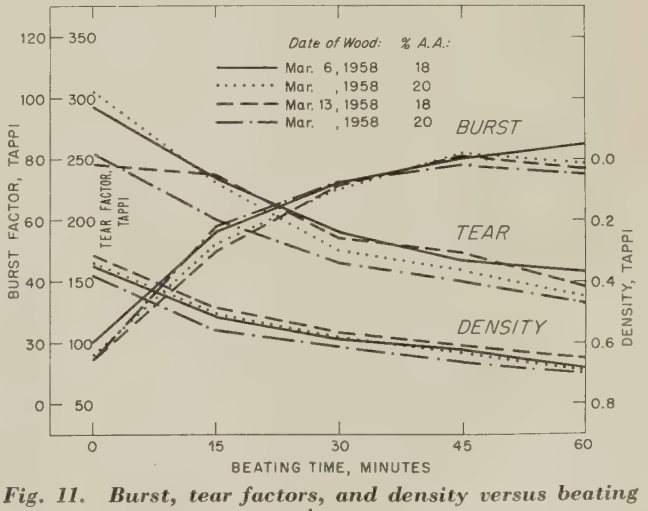

Fig. 11. Burst, tear factors, and density versus beating time

Table VI. Strength Data-TAPPI Standard Beater Tests at Various Beating Times (Unbleached Pulps)

Cook no.	Active alkali, %	Canadian freeness 0	15	30	45	60	Density 0	15	30	45	60	Burst factor 0	15	30	45	60	Tear factor 0	15	30	45	60	Tensile 0	15	30	45	60
											Date of Wood—March 6, 1958														
134	18.0	728	722	544	353	176	0.35	0.52	0.59	0.64	0.67	19	57	75	81	85	292	222	189	170	159	13.1	26.3	34.0	33.6	34.7
135	18.0	734	726	560	361	187	0.35	0.50	0.57	0.61	0.65	21	55	70	79	86	294	244	190	165	157	13.2	26.0	31.2	33.7	35.3
	Average	731	724	552	357	181	0.35	0.51	0.58	0.62	0.66	20	56	72	80	85	293	233	189	167	158	13.1	26.1	32.6	33.6	35.0
136	20.0	731	685	533	322	157	0.34	0.52	0.59	0.62	0.68	16.5	52.7	71.7	82.5	79.6	318	242	177	164	147	11.9	25.6	31.4	32.8	34.2
137	20.0	730	704	547	316	160	0.34	0.51	0.59	0.63	0.68	15.2	51.2	69.0	81.0	78.2	295	222	174	152	132	12.0	24.2	32.2	34.7	33.4
	Average	730	694	540	319	158	0.34	0.51	0.59	0.62	0.68	15.8	51.9	70.3	81.8	78.9	306	232	275	158	139	11.9	24.9	31.8	33.7	33.8
											Date of Wood—March 13, 1958														
138	18.0	726	721	612	397	210	0.32	0.49	0.57	0.61	0.65	15.3	51.3	73.0	81.5	81.0	246	245	186	173	152	11.7	24.8	31.4	33.9	34.3
139	18.0	733	708	592	381	202	0.31	0.49	0.57	0.62	0.65	14.5	48.0	67.8	81.0	84.6	248	230	185	173	140	9.5	22.0	29.7	33.4	34.6
	Average	729	714	602	389	206	0.31	0.49	0.57	0.61	0.65	14.9	49.6	70.4	81.2	82.8	247	237	185	173	146	10.6	23.4	30.5	33.6	34.4
140	20.0	725	677	502	288	130	0.37	0.56	0.61	0.66	0.69	13.3	54.7	70.0	77.5	78.8	262	200	175	156	136	8.7	25.7	30.6	33.4	35.0
141	20.0	729	667	481	258	113	0.39	0.57	0.61	0.66	0.71	16.2	60.6	74.0	80.0	72.3	244	202	156	146	130	11.0	27.4	31.9	34.0	33.7
	Average	727	672	491	273	121	0.38	0.56	0.61	0.66	0.70	14.7	57.7	72.0	78.7	75.5	253	201	165	151	133	9.8	26.5	31.2	33.7	34.3

The effects of various woods upon pulp qualities have been well illustrated by Bray and Curran (*2*), Holzer (*5*), and Holzer and Lewis (*6*). From these works it is obvious that not only will pulp qualities be affected by wood species alone but by variations in the woods of the same species. Therefore, it follows that the variations experienced from day to day in pulp quality could be caused by changes in the nature of the wood supply. Since it appears that these wood variations cannot be effectively corrected by changing the cooking conditions, mill operations are difficult to maintain on a uniform basis due to wood variations caused by uncontrollable factors such as, cite, age of trees, season of the year, etc. In this respect Harold Mitchell of the U. S. Forest Products Laboratory made the following statement: "quality controls starts in the woods, not in the pulp mills." Apparently, differences in pulpwoods influence pulp quality and a considerable amount of research is required to determine the actual effects of these differences upon the papermaking qualities of pulps. It is gratifying that a TAPPI Forest Biology Committee has been recently organized to secure information on this topic, because due to the fact that wood represents the main raw material such information could prove most useful to the industry.

If shorter cooking times and higher maximum temperatures were adopted at the Palatka mill to increase production without increasing the present digester space, this work should be repeated to determine the effects of a large alkali charge under the new time-temperature cooking schedule. It is possible that these effects may vary considerably under the new cooking conditions from those observed in this work by the use of mild cooking conditions.

Where mill water had to be used in this work to wash the experimental pulps, the relative brightness of these pulps could not be reliably determined. Furthermore, no attempt was made to secure data on the effects of the high active alkali charge upon the operation of the recovery units and the paper machines. Since this information could only be secured by conducting extended mill trials, this phase of the problem is beyond the scope of this project.

From the experimental data reported here the following general conclusions have been drawn:

1. A reduction of the active alkali charge from 18 to 16% (i.e., by about 12%) did not appreciably change the yields, rejects and the beatability of the pulps, but led to a slight reduction in tensile and burst strengths of the pulps.

2. An increase in the active alkali charge beyond 18% led to lower accepted yields and rejects, no noticeable change in the beatability of the pulps, and in most cases, a slight increase in tensile and burst strengths.

3. Differences in the morphological and biological nature of woods of the same or related species may have sufficient influence upon experimental pulping data to give variable and possibly misleading results. Such contingencies must be carefully considered in drawing up conclusions and recommendations from experimental pulping data.

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Electrically-Conductive and Static-Free Papers

MASON HAYEK

Organic chemicals have been found which can be used to make paper electrically conductive or to eliminate the static problems widely known in the paper and printing trades. This article briefly reviews the principles of static electrification and describes the mechanism of action of conductive chemicals and the properties of papers treated with these chemicals. A continuous film of conductive agent must cover the cellulose fibers of the paper. Coverage of the surface of the paper is enough for antistatic action, but coverage of the fibers through the bulk of the sheet is essential for conductive treatments. The chemicals function by adsorbing water and reducing the electrical resistance of the paper. The agents can be coated or padded onto paper for conductive effects and, also, can be sprayed for antistatic effects. Several types of conductive chemicals are discussed. The effectiveness of an agent depends upon its concentration, the nature of the paper, and the method of treatment.

THE development of new duplicating processes which require the use of electrically conductive paper will make the application of conductive organic chemicals to paper increasingly important. The production of conductive paper is really an extension of the elimination of static electricity on paper by chemical means. This article summarizes laboratory research on organic chemicals which are useful for conductive or antistatic treatments of paper, and the facts reported here may be helpful in the selection and mill use of these chemicals.

It is convenient to consider first the application of antistatic agents to paper and then show how this treatment can be extended to make paper electrically conductive along both surfaces and through the bulk of the sheet.

MECHANISM OF STATIC GENERATION

In the production and conversion of paper, static arises from friction between the paper web and the machine, between portions of the web, and between sheets as they move in a stack or are separated from one another. E. Bitterli recently reviewed the effects of static in the paper industry (*1*).

The difficulties resulting from static in the printing trade were reviewed in a symposium held in 1949 (*2*). It was stated there that paper stock coming into a printing plant could carry a static charge. Every time a sheet or web passes over a roller there is static generation. It is particularly serious in high-speed printing. In bindery operations, static interferes with jogging and sheeting and with the operation of the folding machines. It would be difficult to estimate the total cost due to spoilage of paper and extra time required to cope with the static. The effective control of static in a printing plant would permit faster operations than are now possible, resulting in a considerable saving.

There are other uses for paper, as in the photographic trade, where the control of static is essential.

Static electricity involves an excess or deficiency of electrons on a surface, as compared with the number of electrons required for electrical neutrality. Electrification occurs when two surfaces which have been in contact are separated. Friction between surfaces means repeated contacts and separations, resulting in repetition of the charging process. The two surfaces in contact have unequal affinities for electrons, and an electrical double layer is set up between the surfaces. When contact is broken, the double layer is ruptured, leaving an excess of electrons associated with one surface and a deficiency with the other. This is a greatly simplified picture of the charging process. More complete descriptions are given in the literature (*3*, *4*).

Many investigators have devised "electrostatic series," or "triboelectric series," of substances. One such series is given in Table I. The order of materials in the series is such that when two substances are rubbed together, the one higher in the list assumes a positive charge and the lower one a negative charge. That is, the higher one loses electrons and the lower one gains electrons.

Such a series is really only a convenient rule of thumb because the net charge transferred across the boundary is dependent upon many factors. In fact, Shaw and Leavey (*5*) found that at least ten factors are involved in the charging process.

Table I. Electrostatic Series

Positive End
Glass
Nylon
Wool
Cotton
Paper
Steel
Rubber
Polyethylene
Negative End

Although we cannot predict quantitatively the extent of charging of a paper surface because of the many factors involved, we can say with certainty that the net amount of charge at the point of contact on a surface after a given time will be a function of the electrical resistance of the paper. The smaller the resistance, the faster the charge will be distributed over the surface of the paper or dissipated to the ground. The decrease in electrification of paper with increasing relative humidity of the environment and increasing moisture content of the paper depends upon the decreased electrical resistance of the paper.

There are two methods by which a chemical on paper could prevent electrification. First, the coating of the product on the paper could provide a new surface which would be electrically equivalent to the surface being contacted—i.e., occupy the same position in the elec-

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Table II. Identification of Papers Treated with Conductive Chemicals

Paper	Type	Ash, %	Fiber content	Caliper, mils	TAPPI Std. ream wt. (25 × 40–400)
A	Coating base stock	18.5	65% Bleached sulfite 35% Bleached soda	3	46
B	Coated magazine paper	24.0	70% Groundwood 25% Bleached sulfite 5% Bleached kraft	3	46
C	Coated book paper	10.0	35% Bleached kraft 65% Bleached hardwood	7	105
D	Filter paper	<0.1	100% Rag	10	66
E	Bond paper	6.5	85% Bleached sulfite 15% Rag	3	42
F	Enameled paper		40% Bleached kraft 60% Bleached hardwood	6	84
G	Folio paper	14.0	25% Bleached rag 10% Bleached kraft 65% Bleached sulfite	4	53

trostatic series—and little net charge would be transferred. Or, secondly, the chemical could reduce the electrical resistance of the paper so that the charge is dissipated over the entire surface or to the ground so fast that little or no charge can accumulate at the point of charging.

It can be seen that the first method is unsatisfactory because the paper may come into contact with a great variety of other surfaces but could be made similar to only one. Therefore, a practical antistatic agent must function by the second method, i.e., by lowering the resistance of the paper. This hypothesis is fully supported by experience with antistatic agents for textiles (*4*, *6*).

Like the electrification process, the prevention of charging by chemical treatment is a surface phenomenon. The electrical resistance that must be controlled is the resistance along one or both surfaces of the paper. Modification of the bulk resistance is incidental.

MEASUREMENT OF ELECTRICAL PROPERTIES OF PAPER

Instruments are available for measuring the electrostatic charge developed on paper under plant or laboratory conditions. This gives a direct measurement of static propensity. In the mill, the most convenient instrument for this is probably a portable electrostatic voltmeter, several types of which are on the market. In the laboratory we have obtained reliable data with a static tester that was described in the literature (*7*). This instrument measures the total charge developed by friction and also the rate of decay of the charge.

A second type of instrument for studying the electrical behavior of paper is a resistance meter designed for measuring resistances above 10^6 ohms, or 1 megohm. Again a variety of instruments are available. The one we have used for most of the data in this article is described in the literature (*8*). The resistance meter is useful for testing either antistatic or conductive treatments. It has been established that for paper, as for textiles, if the resistance is low enough the static generation will be small. The exact level of resistance permissible for controlling static in a specific situation must be determined by experience. Once that level is set, then a simple test can be used to screen all products and treatments.

The resistance meter gives readings of resistances directly. For surface measurements, these can be converted to resistivities, or resistances per square area, by multiplying the observed resistance by the ratio of the width of the test paper to the distance between the electrodes. For convenience, we report the logarithm of the resistivity, designated here as log R_S.

The resistance tester can also be used to measure bulk resistance of paper. In the instrument, stainless steel electrode blocks are supported on pieces of Lucite* which have the same surface dimensions ($3^3/_4 \times {}^3/_4$ in.) as the electrodes. For the usual surface resistivity test, the test specimen is mounted between the Lucite and the stainless steel and extends the distance between the electrodes (0.5 in.). For the measurement of bulk resistance, we place a 1-in. wide strip of aluminum foil between the electrodes where the test specimen is normally mounted, and then place the test paper, of width slightly greater than 1 in., between the bottom of one electrode and the aluminum foil. The electrical resistance measured under this situation is then the bulk resistance of the paper over an area of 0.75 sq. in. Again, the bulk resistance is normally reported in terms of its logarithm and is designated log R_B. It should be noted that the bulk resistance is a value which depends upon the dimensions of the equipment and specimen. On the other hand, the surface resistivity is a measure of the electrical resistance per square area and the data are independent of the shape and spacing of the electrodes.

The logarithms of the surface electrical resistivities of a number of papers between 25 and 63% R.H. are given in Fig. 1. These papers and the ones discussed in other sections are identified in Table II. The slopes of the straight lines joining the logarithms of the resistivities are between −0.040 and −0.074 logarithm unit per 1.0% R.H. Murphy and Walker (*9*) found that for cotton between 20 and 80% R.H. the relation between the resistance and the R.H. was given by the following equation.

$$\log R = -0.085\, H + A,$$

where R is the resistivity, H is the relative humidity in per cent, and A is a constant, depending on the sample, the electrode system and whether the sample was adsorbing or desorbing. In the corresponding equation for our data for a particular paper, the value −0.085 would be replaced by the slope for the appropriate line in Fig. 1.

* Registered trademark of E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

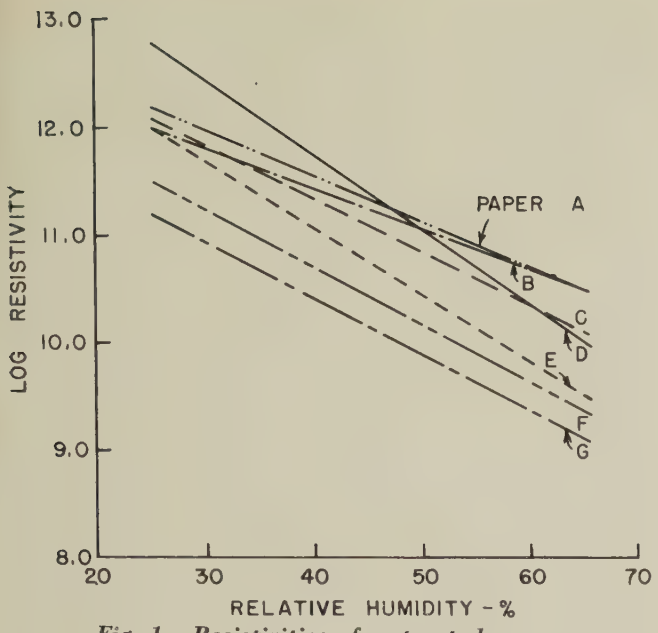

Fig. 1. Resistivities of untreated papers

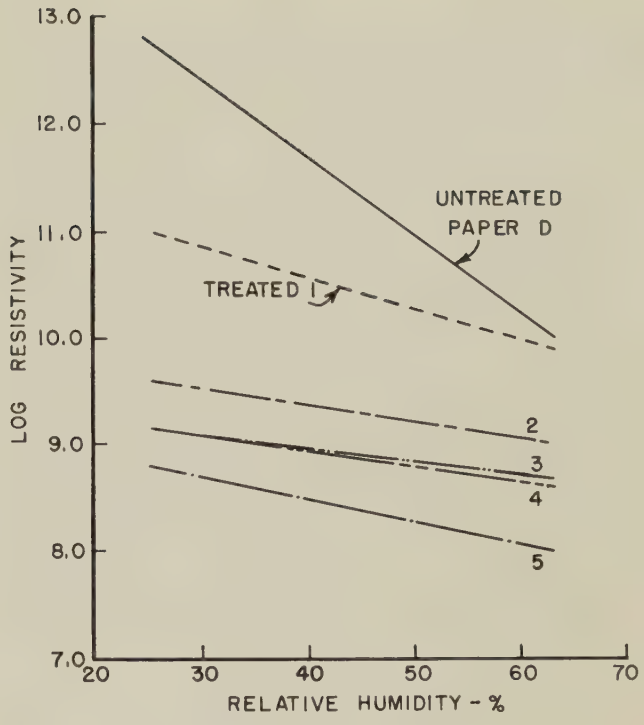

Fig. 2. Dependence of product effectiveness on relative humidity

Hysteresis effects occur in the relation between electrical resistivity of paper and relative humidity. For this reason, we customarily condition test papers by holding them briefly at a humidity above that to be used in the test and then reducing the humidity to the desired level.

MECHANISM OF ANTISTATIC ACTION

The degree of electrification of paper under a given set of conditions depends upon the surface electrical resistivity of the paper, as shown in Table III. These data are for 25% R.H. The papers tested had been treated with antistatic agents to give the range of resistances shown. Charges were developed in the static tester mentioned previously (7) by friction against rubber. The *charges* are proportional to the voltages and are actually the currents in microamperes produced in an electronic circuit by the charges on the papers. The half-life periods are the times required for the charges to drop to one-half of their peak values after friction was stopped. It is evident from the table that the greater the resistance, the greater the charge and the longer the time required for the charge to be dissipated.

No general statement can be made about the extent of charging that is permissible in a paper mill or a printing plant. This must be determined by experience in the particular operation. In laboratory work, it is most convenient to compare antistatic agents and methods of treatments by measuring the electrical resistivities of the treated paper. The information on relative effectiveness of the various treatments can then be applied in a selection of conditions for mill applications.

Table III. Dependence on Charge Generation on Electrical Resistivity

25% R.H.

Log Rs paper	*Charge versus rubber*	*Half-life sec.*
9.9	40	1
10.5	100	1
10.6	100	1
10.7	125	2
11.2	150	2
11.8	200	3

In a systematic study of antistatic agents for paper, it is necessary to have a suitable hypothesis to explain how antistatic agents can lower the electrical resistance of paper. The experimental results with all organic antistatic agents we have tested indicate that the reduction in resistance is caused by the adsorption of water by the antistat on the cellulosic fiber surface. Evidence for this has been obtained from the study of both textiles and paper. The mechanism of conduction of electricity on the surface of the paper on which the antistatic agent is deposited is uncertain, but it is probably ionic in nature, rather than electronic.

Data for the variation of electrical resistivities of treated paper with variations of relative humidity show the dependence of antistatic action on relative humidity. Such data are shown in Fig. 2. The effect of relative humidity on the resistivity of the untreated paper is shown for comparison. The resistivities of the treated papers are markedly below the resistance of the untreated paper. They are dependent upon the relative humidity but the slopes of the lines for the treated papers are less than the slopes for the untreated paper, being approximately -0.02.

In Fig. 2, Treatment 1 consisted of 1.0% ethylene oxide condensation product on the paper. Treatments 2 and 4 were with 1.0 and 2.0% of an amine salt. Treatments 3 and 5 were with 1.8 and 3.6% alkyl phosphate. The amounts of antistats used in a mill might be as low as 0.1 to 0.5%.

It has long been known that certain humectants, such as glycols, and certain inorganic salts, such as sodium chloride, decrease the tendency of paper to become charged. The glycols function as inefficient antistatic agents. On the other hand, the inorganic salts decrease the resistivity of the treated paper by providing ions for the water normally adsorbed by the

paper. In most cases, the inorganic salts are not a satisfactory solution for the static problem because of their corrosive effects on metal equipment and their failure at low humidities.

It has already been stated that static electrification is a surface phenomenon and, therefore, an antistat to be effective must be on the surface of the cellulose fibers. An additional requirement is that the antistat-water units on the surface of the fiber form a continuous film. Discontinuities will cause marked increases in the electrical resistance along the path crossing the discontinuity. Therefore, the amount of antistatic agent deposited on the paper must be at least sufficient to provide a monomolecular film over the entire surface of the paper. Because of great irregularities in the surface of the paper, this will require considerably more agent than would theoretically be necessary for a monomolecular film.

MECHANISM OF ACTION OF CONDUCTIVE AGENTS

Conductive treatments of paper differ from antistatic treatments only in degree. Generally, an electrically conductive paper is defined as one with a surface resistivity in the semiconductor range of 10^8 to 10^{10} ohms over 25 to 80% R.H., whereas resistances higher than these by a factor of 10 may be suitable for static-free papers under most conditions. In addition, conductive papers must have reduced bulk electrical resistance, from one side of the sheet to the other. The extension of antistatic to conductive treatments then merely requires the use of additional or more effective chemical and a method of application which reduces both the surface and bulk resistances. The method of treatment will be considered in the following section.

The mechanism of action of a conductive chemical is identical to that of antistatic agents. The same chemicals may be used for conductive and antistatic effects. The papers 2, 3, 4 and 5, described in Fig. 2, were sufficiently conductive for use in the new duplicating processes because not only were the surface resistivities of the right magnitude, but the bulk resistances were proportionately below the bulk resistance of the untreated paper.

All the conductive chemicals we have tested function by the adsorption of water by the chemical on the cellulosic fiber surfaces. Whereas for antistatic effects the antistat must form a continuous film along the fibers on the surface of the paper, for bulk conductive effects the agent must also form a continuous film along the cellulose fibers throughout the sheet.

In routine testing of paper treatments, it is convenient to measure only the surface resistivities of the sheets after it has been established that a particular application procedure for a specific product reduces the bulk resistances proportionately to the reductions in surface resistivities.

APPLICATIONS OF CONDUCTIVE AND ANTISTATIC CHEMICALS

Conductive effects may be achieved by coating an aqueous solution of the chemical on the paper or padding the paper with a solvent solution of the agent. Antistatic effects can be achieved by these techniques or by spraying a solution of the chemical on the paper. The concentration of chemical required on the weight of

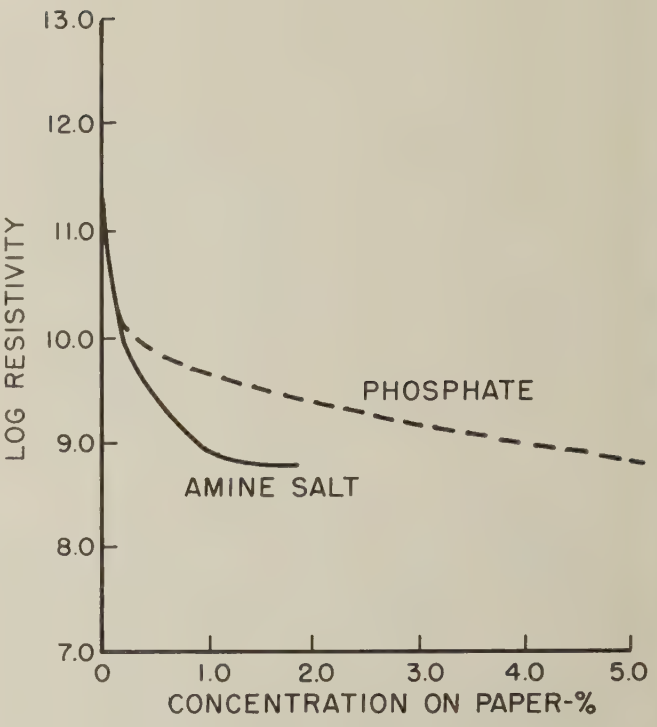

Fig. 3. Dependence of product effectiveness on concentration (paper D)

paper for conductive treatments is 0.5 to 4.0%. The concentration required for antistatic effects is 0.05 to 0.5%. It is essential for either effect that the application be made under conditions which will not cause appreciable swelling of the cellulose fibers.

The most practical treatment of a sized paper with a conductive chemical involves coating an aqueous solution of the agent on one side of the paper at a wet pickup near 10% and no higher than 20%. This pickup is low enough that little or no swelling of the fibers occurs, but the solution penetrates the paper so that the surface resistances of both sides of the sheet and also the bulk resistance are reduced. If the paper does not contain size, it is difficult to make the treatment without swelling the fibers, and the treated paper may have about the same electrical properties as the untreated. In some cases, the use of sodium carboxymethylcellulose or sodium alginate may be necessary to increase the viscosity of the coating mixture to reduce penetration of the paper. In the laboratory, coating can be conducted conveniently with a hand wringer which picks up the solution on the bottom roll from a pan into which the roll dips. In the mill, similar effects can be achieved at the size press of a paper machine or in an off-machine coating operation.

The padding of paper with a solvent solution of the conductive chemical is convenient in the laboratory and perhaps useful in some mills. Full immersion of the paper in the solvent solution, followed by squeezing and drying, causes a reduction in surface and bulk resistances at least as great as achieved by any other method of application. Suitable solvents are alcohols, such as ethyl or isopropyl alcohol; hydrocarbons, such as benzene or toluene; chlorinated hydrocarbons, such as trichloroethylene or perchloroethylene; and ketones, such as acetone or methyl ethyl ketone.

Since application of a conductive chemical to only one surface of a sheet at fairly low concentration is

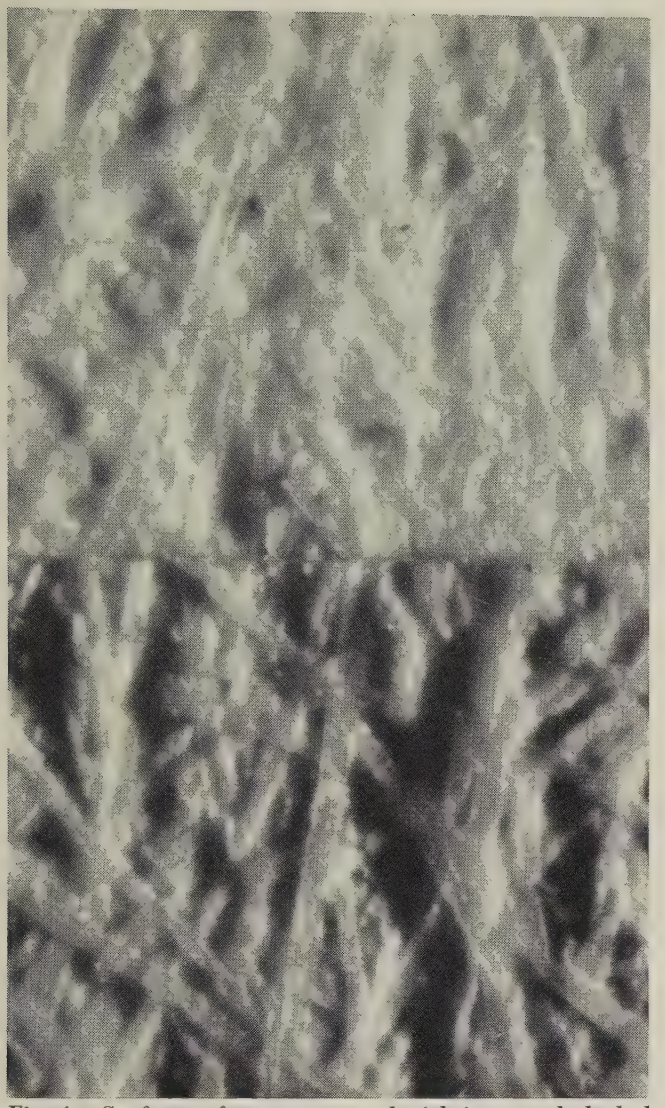

Fig. 4. Surfaces of papers treated with isopropyl alcohol (upper) and water solutions (78×)

sufficient for antistatic effects, spraying of the aqueous solution of antistat is practical. The application may be made near the source of static troubles, as on a printing press. Of course, the sheet must not become wet enough that the fibers swell appreciably. It is difficult in the laboratory to simulate mill spraying, but the operation was carried out with an aspirator connected to a compressed air line.

The variations of electrical resistivities with concentrations of two conductive agents on paper are shown in Fig. 3. The agents were applied from isopropyl alcohol solutions so that there could be no interference from swelling of the fibers. For the paper used here, the amine salt reduced the resistivity markedly at concentrations above 0.04% and the phosphate was effective above 0.1%.

The reason for the failure of treatments below 3% when the bulk of the cellulose fibers is wet is probably related to the need for a continuous film of antistat on the paper. Wetting of the bulk of the paper with aqueous solution causes swelling of the fibers, followed by shrinkage on drying. These changes in fiber dimensions cause discontinuities in the deposit of conductive agent on the fiber surfaces. If the fibers are treated in such a way that they do not swell, a continuous film of antistat is formed on the surfaces of the fibers and

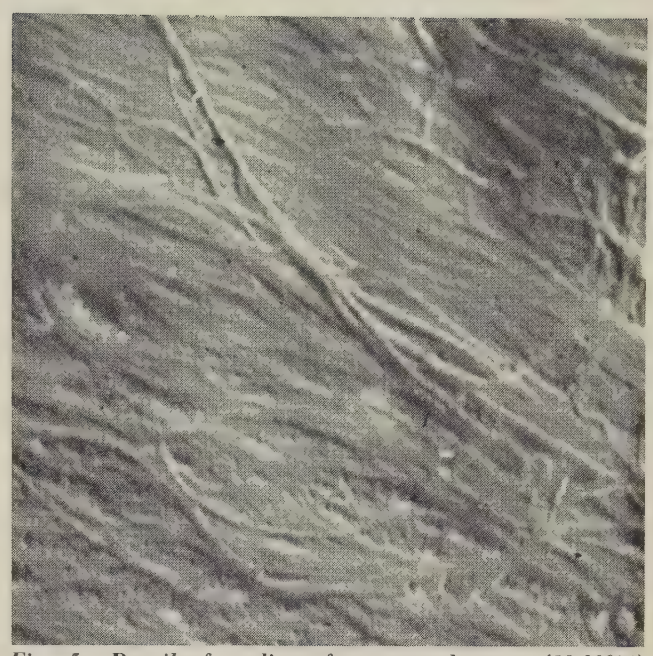

Fig. 5. Detail of replica of untreated paper (10,000×)

between fibers. The effects of fiber swelling may be offset by applying the agent at a concentration higher than 3% on the paper.

This explanation is at least partially supported by photomicrographs and electron photomicrographs of paper surfaces. The paper used was type D of Table II, an unsized sheet. The photomicrograph in Fig. 4 shows the surfaces of two portions of paper originally from the same sheet. The portion at the top had been padded with an isopropyl alcohol solution of an alkyl phosphate to produce a good conductive effect. Under the microscope, there is no difference between this paper and the untreated. The portion at the bottom had been padded with an aqueous solution of the same phosphate, but the resistivity of the paper was no lower than that of the untreated paper. The great extent of disruption of the fibers in the paper treated with the water solution is evident. The disruption caused by the water treatment would have a great effect on the continuity of the antistat film. The glossiness of the paper at the top is due only to reflected light from the fairly smooth surface.

The electron photomicrographs in Figs. 5 through 9 show replicas of fiber surfaces at 10,000× magnification. Great detail of fiber structure is visible in the photographs of the untreated fibers (Figs. 5, 6, and 7) but in the other two photographs the conductive chemical is spread over the fibers and obscures the fine detail. The photographs shown are typical of the many taken. There is a strong suggestion of nonuniformity of deposit on the fibers treated with the antistat in water. The electron photomicrographs definitely located the chemical on the surfaces of the fibers after either the alcoholic or aqueous application.

Two methods were used for the replica studies. Figures 5, 8, and 9 involved embedding $^1/_2$-in. squares of paper in polystyrene, stripping the paper from the plastic and shadow casting with a palladium-platinum alloy, followed by coating with carbon. The shadowed metallic replica was then floated off in ethylene dichloride, washed, and mounted in specimen screens for the electron microscope.

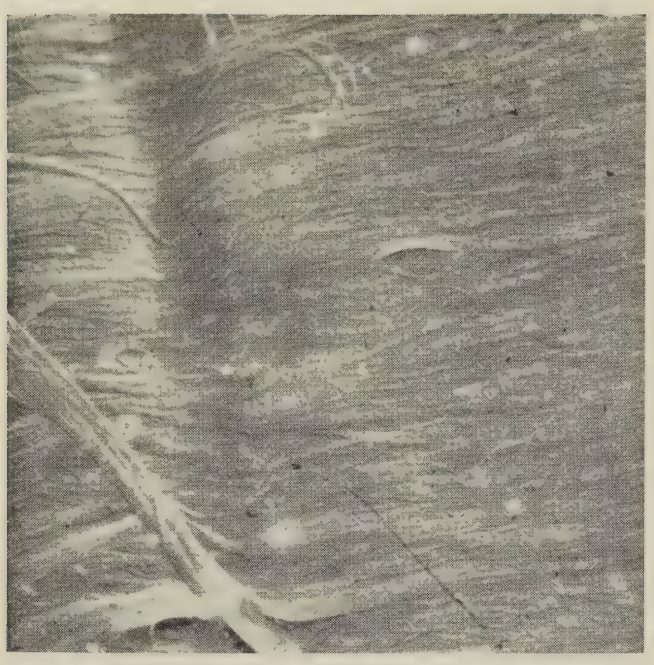

Fig. 6. Detail of replica of paper treated with water (10,000×)

The preparation of Figs. 6 and 7 involved shadow casting the alloy directly on the paper and coating with carbon. The coated paper was embedded in polystyrene and then stripped from the plastic, leaving the metallic casting embedded. The shadowed replica was then removed from the plastic and mounted, as for the other figures.

We have observed a great dependence of effectiveness of treatment upon the nature of the paper. This is probably due in part to differences in the amount and nature of internal and surface sizes, fillers, and coatings. These relationships are not yet known, however. In general, the order of effectiveness of a group of products on one paper is the same as on another.

The dependence of effectiveness of a particular product on the nature of the paper is shown by the data in Table IV. The logarithms of surface resistivities are given for several papers, untreated and treated with three different products. The data show that the precise treatment necessary must be patterned to meet the particular properties required of the paper. No general formula can be offered.

The data in Tables V, VI, and VII show examples of the reductions in electrical resistances achieved by coating aqueous solutions, padding solvent solutions and spraying aqueous solutions of conductive chemicals onto several papers. The spraying produced antistatic effects on one side of the sheet. In Tables V and VI both the surface and bulk resistances are reported. All treatments were made in the laboratory but the results should be easily duplicated in a mill.

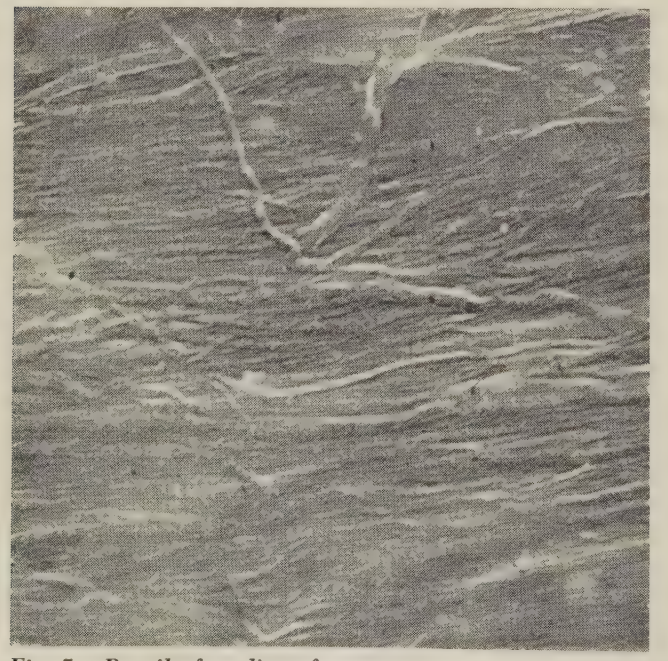

Fig. 7. Detail of replica of paper treated with isopropyl alcohol (10,000×)

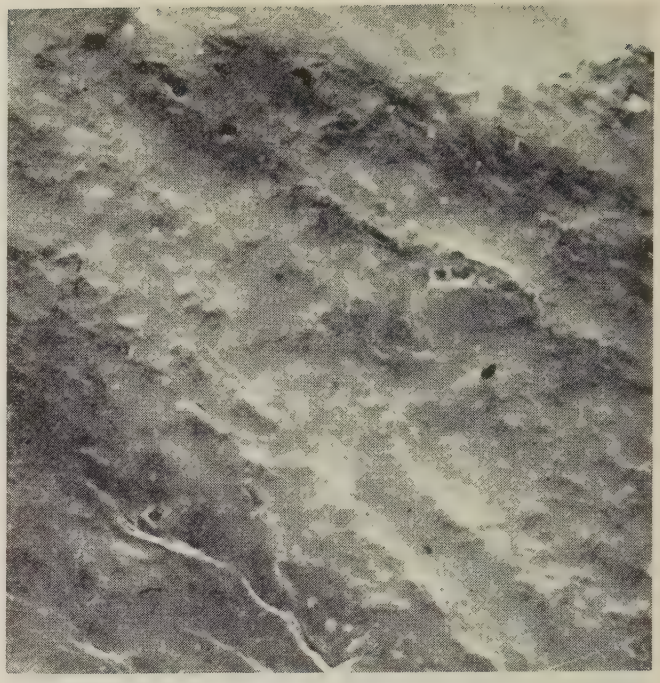

Fig. 8. Detail of replica of paper treated with alkyl phosphate in isopropyl alcohol (10,000×)

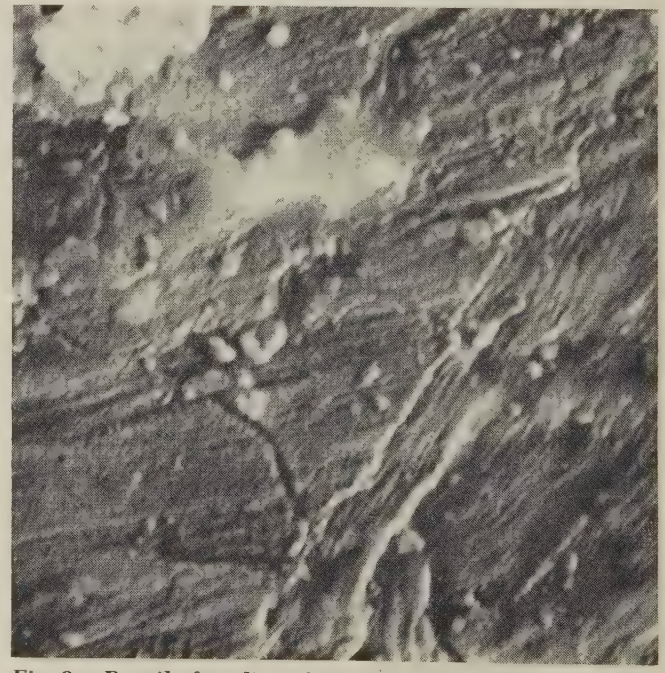

Fig. 9. Detail of replica of paper treated with alkyl phosphate in water (10,000×)

Table IV. Variation in Effectiveness of Product with Nature of Paper

Paper[a]	Product applied	Log Rs, 25% R.H. Treated paper	Log Rs, 25% R.H. Untreated paper
D	Alkyl phosphate I	9.6	12.8
E		10.4	12.0
B		11.2	12.0
D	Alkyl phosphate II	9.6	12.8
E		10.4	12.0
G		10.9	11.3
C		10.3	12.2
F		11.3	11.3
D	Amine salt I	8.9	12.8
G		9.5	11.3
C		9.3	12.2
F		10.5	11.3

[a] See Table II.
1.0% Product on paper applied by padding from isopropyl alcohol solution.

RELATION OF CHEMICAL STRUCTURE TO CONDUCTIVE ACTION

There is little information in the prior art on the types of chemical structures which provide conductive effects on paper. Some information on this relation can be gained from a study of the literature on antistats for textiles. However, it must be recognized that not all conductive chemicals for one substance are effective on another.

Alkyl phosphates, amine salts, quaternary ammonium salts, and polyoxyethylene derivatives have been mentioned in this report. In any class of products, some chemical structures are much more effective than others. Compounds of closely related compositions may differ greatly in their properties.

There are a few references in the literature to other chemical types of conductive agents. Inorganic compounds, which do not function like organic products and are generally much less effective for a given weight, have been suggested for use as antistatic agents and to

Table V. Conductive Agents Coated on Paper

Product applied	Paper[a]	Concn. on paper, %	Log Rs, 25% R.H. Treated paper	Log Rs, 25% R.H. Untreated paper	Log RB, 25% R.H. Treated paper	Log RB, 25% R.H. Untreated paper
Amine salt I	E	0.5	10.7	11.8	9.5	9.9
	E	1.2	9.4	11.8	8.6	9.9
	E	1.4	9.2	11.8	8.3	9.9
	A	1.5	8.9	13.0	9.9	11.2
	C	0.8	9.0	12.2	...	...
	G	0.4	10.9	11.3	...	...
Amine salt IV	E	1.8	9.7	11.8	8.3	9.9

[a] See Table II.

make paper conductive. These include metals (*10*), carbon (*11*), and some inorganic salts (*12*). Among organic compounds described are mono- and polyhydric alcohols (*10*, *12*) and sulfonates (*13*).

The common characteristic of organic conductive agents is the ability of a functional group in the molecule to adsorb water The differences in effectiveness of a given product on different papers may mean that there are differences in the nature of association of the molecules with the different papers. Little is known of this phenomenon. It is certain that hygroscopicity alone is not a good criterion of a compound's properties.

PRACTICAL CONSIDERATIONS

Some inportant considerations for the application of conductive agents in any paper or printing mill are the

Table VI. Effects of Padded Conductive Agents on Paper D[a]

Product Applied[b]	Concn. on paper, %	25% R.H. Log Rs	25% R.H. Log RB
None (untreated paper)	...	12.8	11.5
Alkyl phosphate I	1.0	10.6	8.8
	2.0	10.3	8.3
Amine salt I	0.4	9.6	<7.9
	0.8	9.1	<7.9
Amine salt II	0.4	9.6	8.2
	0.8	9.0	<7.9
Amine salt III	0.4	9.9	8.5
	0.8	9.4	<7.9
Ethylene oxide Condensate I	1.0	11.2	8.9
	2.0	10.9	9.3
Quaternary ammonium salt I	0.4	11.2	9.8
	0.8	10.9	9.5

[a] See Table II.
[b] Padded from isopropyl alcohol solution.

cost, the type of equipment required for treatment, and the effects of the treatments on the physical properties of the paper. The minimum cost for an antistatic agent would be about $0.50 per ton of paper. For any specific application, the total cost would, of course, be determined not only by the cost of the chemical but also the cost of the treatment, including drying and labor costs, which could be expected to be small. A conductive treatment would cost more because of the larger amount of chemical used.

Conductive chemicals can be applied on the paper machine at the size press or, probably, at the calender stack. They may also be applied off the machine in a coating operation or, if a solvent can be used, in a padding operation.

A variety of conductive organic chemicals possessing a range of physical properties is now available to the paper trade. For the solution of a particular static problem or the preparation of conductive paper for a specific end use, that treatment must be selected which will give an optimum combination of properties to the

Table VII. Antistatic Agents Sprayed Onto Paper E[a]

Product applied	Concn. on paper, %	Log Rs 25% R.H.
None (untreated paper)	...	11.8
Alkyl phosphate I	0.5	11.4
	1.5	10.5
Alkyl phosphate II	1.6	11.1
Polymeric quaternary ammonium salt	0.2	11.2

[a] See Table II.

treated paper. In some cases, electrical conductivity alone is important. In other cases, frictional or other properties of the treated paper will be very important. The information now available on the behavior of conductive agents points to the practical solution of conductivity and static problems within the limitations imposed by the other requirements for the paper.

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Some Developments in Swedish Sulfite Pulping Research

LENNART G. STOCKMAN

A review of some sulfite cooking projects at the Central Laboratory of the Swedish Cellulose Industry. Sulfite cooking without base is possible under certain conditions and gives paper and viscose pulps with normal yield-chlorine number relationships and normal characteristics. The sulfonation can be accelerated by small additions of a base or a soluble sulfate. Single stage sulfite cooking with $NaHSO_3$, a process which gives high yields of bright chemical pulps with strength properties that are in some respects comparable with those of kraft pulps, and two-stage sulfite cooking are also discussed.

Competition from sulfate pulp, water pollution problems and the higher cost of production are all factors that have stimulated research on new ways of making sulfite pulp. This paper deals with a number of more or less unconventional ways of making sulfite pulp that may help to make the sulfite process more flexible both in production and in the grade of product obtained. It will be limited mainly to the results of investigations into the sulfite process that have been recently completed or are still in progress at the Central Laboratory of the Swedish Cellulose Industry (CCL) in Stockholm.

SULFITE COOKING WITH SO_2 SOLUTIONS

During the last 10 years there has been a steady increase in interest in the use of soluble bases in sulfite cooking. This usually means cooking with magnesium, ammonium, or sodium bases. A great deal has been published on these bases, but relatively few papers have been published on cooking without a base, with an aqueous solution of SO_2. It is no novelty that wood can be pulped with a plain SO_2 solution, but the results published so far show that this usually gives a pulp with a very high lignin content relative to the yield (*1*) and with a low viscosity. In some cases (*2*) a sulfite pulp of normal quality has been obtained only after cooking for several days.

In a sulfite cook there are three principal lignin reactions which occur more or less simultaneously: sulfonation, condensation, and hydrolysis. According to Hägglund the removal of the lignin requires first, sulfonation with HSO_3^- or with undissociated SO_2 and then, hydrolysis of the lignosulfonic acid formed. The question of which of these reactions is rate determining for the release of lignin has recently been studied very carefully (*3*) but is not of major importance here. Under all conditions, however, a definite level of sulfonation (about 0.3 S/OCH_3) is required before the hydrolysis that makes the lignin water soluble can occur. This set of reactions bringing the lignin into solution is counteracted by one or more reactions, partly unknown, that can be referred to as lignin condensation. Condensation is favored by a low pH and a high temperature. In itself it is not a hindrance to the course of sulfonation. Thus, treatment of wood at temperatures well above 100°C. with a plain SO_2-solution will readily give a degree of sulfonation of 0.6 S/OCH_3 even though the lignin is so condensed that a black cook is produced if cooking is continued. In sulfite cooking it is therefore necessary to choose conditions under which the rate of condensation of the lignin is as low as possible relative to the sulfonation.

Richter (*1*) in a series of experiments has thrown

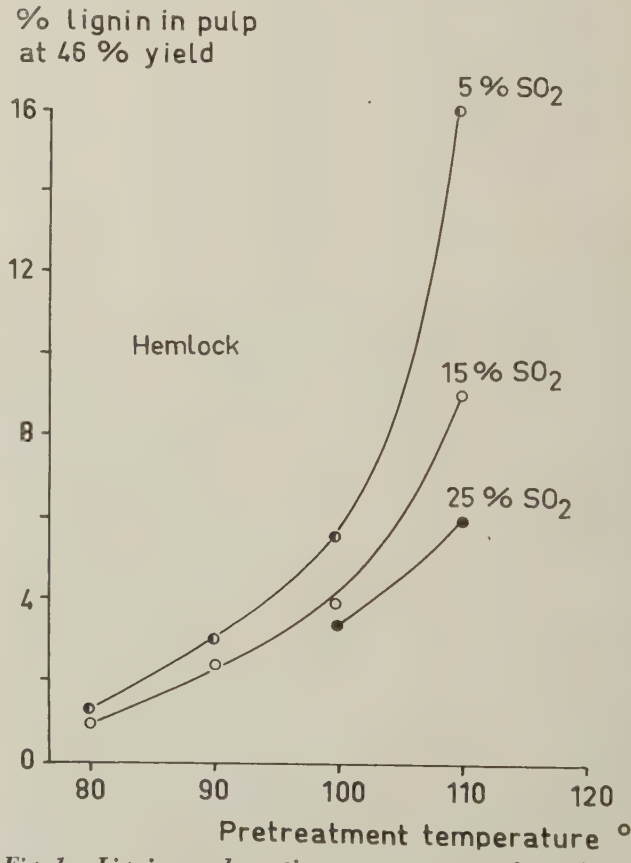

Fig. 1. Lignin condensation on treatment of wood chips with SO_2 solutions

Lignin condensation as indicated by lignin content at constant pulp yield after 4-hr. treatment with SO_2 solution followed by a standard sulfite cook.

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some light on the extent of condensation as a function of the concentration of the SO_2 solution and the temperature by treating wood chips for 4 hr. with 5, 15, and 25% solutions of SO_2 at temperatures of between 80 and 110°C. before making a standard sulfite cook.

Figure 1 has been prepared from Richter's published results. This shows clearly that a preliminary treatment of chips with SO_2 solution at temperatures above 80° C. leads to an inferior lignin release during the sulfite cook. The lignin condensation effect is less, however, if the SO_2 concentration is higher for any given temperature. This is important and indicates that at higher SO_2 concentration it might be possible to use temperatures of 90 to 100°C. for a plain SO_2 treatment without producing excessive lignin condensation. Figure 1 indicates that at rising SO_2 concentrations the sulfonation reaction is accelerated by the higher SO_2-HSO_3^- concentration to a greater extent than the condensation reaction is accelerated by the simultaneous increase in the hydrogen ion concentration. This indicates a possible way of carrying out the sulfonation stage of a sulfite cook with a solution of SO_2.

The second stage in sulfite cooking can be regarded as a hydrolysis. The rate of this reaction using different bases has recently been studied by Rozenberger (*4*). In his experiments, spruce chips were sulfonated by sulfite cooking in a sodium bisulfite cooking acid at a relatively low temperature (about 100°C.) without dissolving any large part of the lignosulfonic acids. The sulfonated chips were divided into six parts and the sodium ions of the lignosulfonate salts were replaced by H^+, Na^+, NH_4^+, Mg^{++}, Ca^{++}, and Ba^{++} respectively in each of the six parts. The sulfite cook of each of these samples was then continued using a 5% SO_2 solution under identical conditions; this gave the results shown in Table I.

It can be seen that the lignosulfonic acid release, that is mainly hydrolysis, was fastest with hydrogen ion as the only cation. The next fastest rates were in the solutions with a monovalent metal cation together with the hydrogen ion from the SO_2 solution, and the slowest reactions occur with divalent cations together with hydrogen ion. This result is in agreement with the differences described in the literature between sulfite cooks with mono- and divalent bases. From the point of view of the SO_2 cook the most interesting point shown by the Table I is that hydrolysis is fastest in the absence of metal cations. Rozenberger explains the differences between the different cations as a matter of different solubilities. The difference can perhaps better be explained by Hägglund's theory that the rate of solution of the lignosulfonic acid depends on the hydrogen ion concentration in the solid phase.

At constant SO_2 concentration in the surrounding solution and taking into account the Donnan equilibrium, the hydrogen ion concentration of the lignosulfonic acids will fall in the sequence—plain SO_2 solution, monovalent bases, divalent bases. The lower the concentration of metal ions in the cooking liquor the greater will be the proportion of lignosulfonic acids present as free acids and the faster the hydrolysis of the lignin. It can thus be expected that when the sulfonation step has been carried out with a plain SO_2 solution the subsequent hydrolysis should be faster than in an ordinary cook where metal ions are present.

Table I. Rate of Delignification with Different Cations

Cation	*pH of spent liquor*	*Total yield, %*	*Shives, %*	*P-number (TAPPI 25 ml.)*	*Chlorine number (TAPPI T-202 CCA 9 A)*
H^+	1.02	48.7	0.0	5.7	1.7
Na^+	1.10	49.6	0.0	8.2	2.5
NH_4^+	1.11	49.3	0.0	7.8	2.4
Mg^{2+}	1.09	50.4	0.5	16.5	5.7
Ca^{2+}	1.06	50.9	1.6	17.6	6.1
Ba^{2+}	1.09	51.3	2.4	18.6	6.6

Investigations in the CCL laboratory, carried out largely by Civilingenjör Per Rönström, on sulfite cooking using SO_2 solutions alone are not complete but gave some information.

It was first necessary to determine the highest temperature practicable for the sulfonation. The temperature should be as high as possible in order to reduce the sulfonation time needed to a minimum and give the maximum digester capacity. However, it is clear from the preceding discussion, that the temperature is limited upwards by the lignin condensation. Taking these factors into account sulfonation temperatures of 85, 95, and 105°C. were chosen for the experiments. Since, according to Fig. 1, a high SO_2 concentration gives less lignin condensation, this also should be as high as possible. In practice the SO_2 concentration is limtied by the highest permissible digester pressure. A pressure of 15 atm. (220 p.s.i.g.) was selected for the present investigations; it follows that the SO_2 concentration varied with the temperature used.

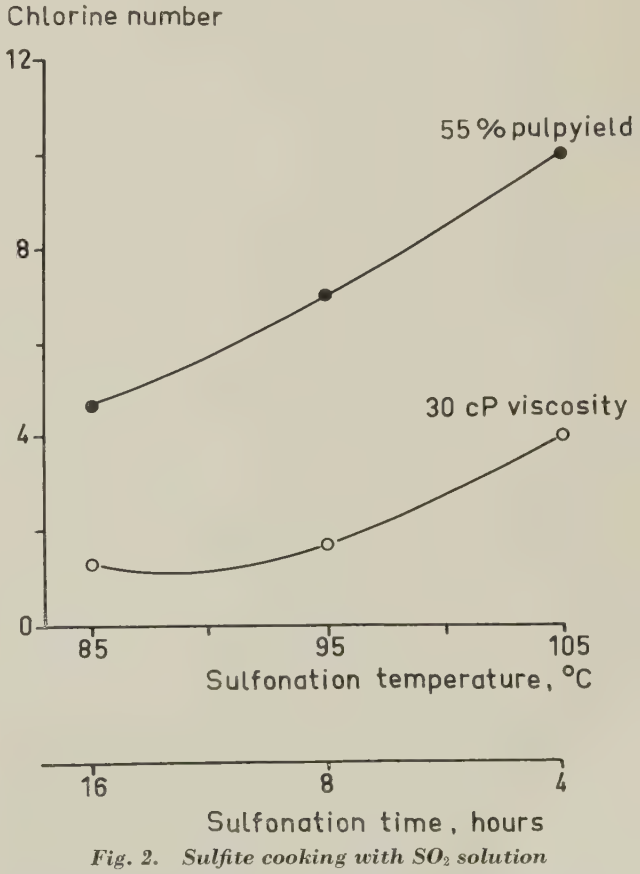

Fig. 2. Sulfite cooking with SO_2 solution

Relationship of chlorine number to sulfonation temperature for constant yield (maximum temperature 115°C.) and for constant viscosity (maximum temperature 145°C.). Maximum pressure 220 p.s.i.g.

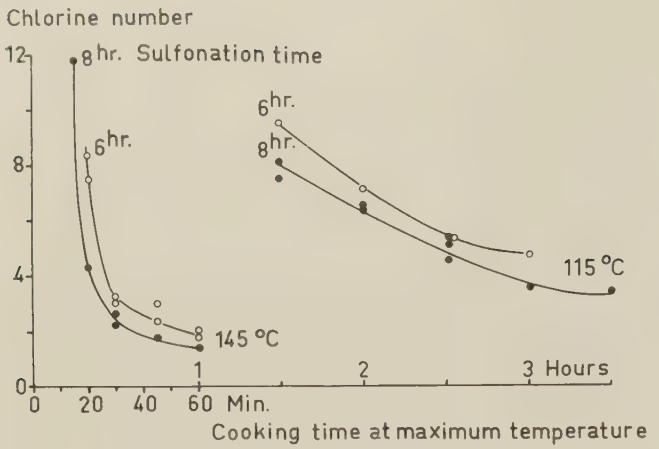

Fig. 3. Sulfite cooking with SO_2 solution

Relationship of chlorine number to cooking time at maximum temperature. Maximum pressure 220 p.s.i.g. Sulfonation temperature 95°C.

To make certain of avoiding any tendency to get a black cook the sulfonation time was prolonged a little beyond that needed for the subsequent lignin hydrolysis. For the three temperatures given above, sulfonation times of 16, 8, and 4 hr., respectively, were selected. After the completion of sulfonation the final cooking was done at 115°C. for paper pulps and at 145°C. for viscose pulps.

The results are shown in Fig. 2 which gives the chlorine number (TAPPI-202, CCA 9 A) at constant yield and a final cooking temperature of 115°C., and the chlorine number at constant viscosity and a final cooking temperature at 145°C. as a function of the sulfonation conditions. A normal paper sulfite cook on the same wood gave a chlorine number of 7 to 8 at 55% yield corresponding, according to Fig. 2, to a sulfonation temperature of 95 to 100°C. A sulfonation time of 8 hr. at 95°C. followed by hydrolysis at 115°C. clearly corresponds to a normal sulfite cook Other experiments have shown that a sulfonation time of 6 hr. at 95°C. gives almost the same result as an 8 hr. sulfonation. Hydrolysis at 145°C. (Fig. 2) obviously gives a chlorine number fairly normal for a viscose pulp of the viscosity given.

Figure 3 shows that the course of lignin release is quite rapid both at 115°C. for pulps sulfonated for 6 and 8 hr. at 95°C. and 15 atm. Both the paper and viscose pulps have normal characteristics compared to those of ordinary sulfite pulps. Even in yields of 58 to 60% the pulps are very easy to defibrate.

Conditions in this type of cook are much more favorable for a steam phase sulfite cook than in the type of cook customary at the present time since the only chemical used, SO_2, can easily spread through the digester by diffusion both in the gas phase and in the liquid phase. A cook using direct steam heating and the same high SO_2 vapor pressure as in the liquid phase cooks should therefore be possible provided the chips contain sufficient water for the reactions that take place.

These experiments showed that it is quite possible to make both paper and viscose pulps by cooking with SO_2 solutions alone. The advantages of this procedure are the elimination of limestone costs and handling, simpler absorption apparatus in place of acid towers, and possibly also a lower SO_2 consumption per ton of pulp, and a higher sugar content in spent liquor. The main disadvantages are the higher pressures required in the digester and hot acid tanks or, alternatively, the longer cooking time. Presumably, compressors for making liquid SO_2 would also be required.

Sulfite cooking with acids containing between 0 and 0.5% of combined SO_2 has been little studied. It is probable however that either the cooking time or the digester pressure could be reduced relative to those in a plain SO_2 cook if the combined content of SO_2 used was much lower than normal, for instance 0.1 to 0.2%. There is, according to Kaufmann (*5*), a relationship between the content of combined SO_2 and the lowest concentration of SO_2 that can be used without risk of a condensation (Fig. 4).

SULFITE COOKING WITH Na_2SO_4 + SO_2 SOLUTION

This leads naturally to another project that has recently been studied at the CCL—to sulfite cooking with SO_2 solution + Na_2SO_4 (*10*). Both Hägglund (*6*) and Richter (*7*, *8*) showed long ago that this was possible but did not study the yield or the quality of the pulp. Nelson and Mannbro (*9*) have elucidated the function of the sulfate in magnesium bisulfite cooking.

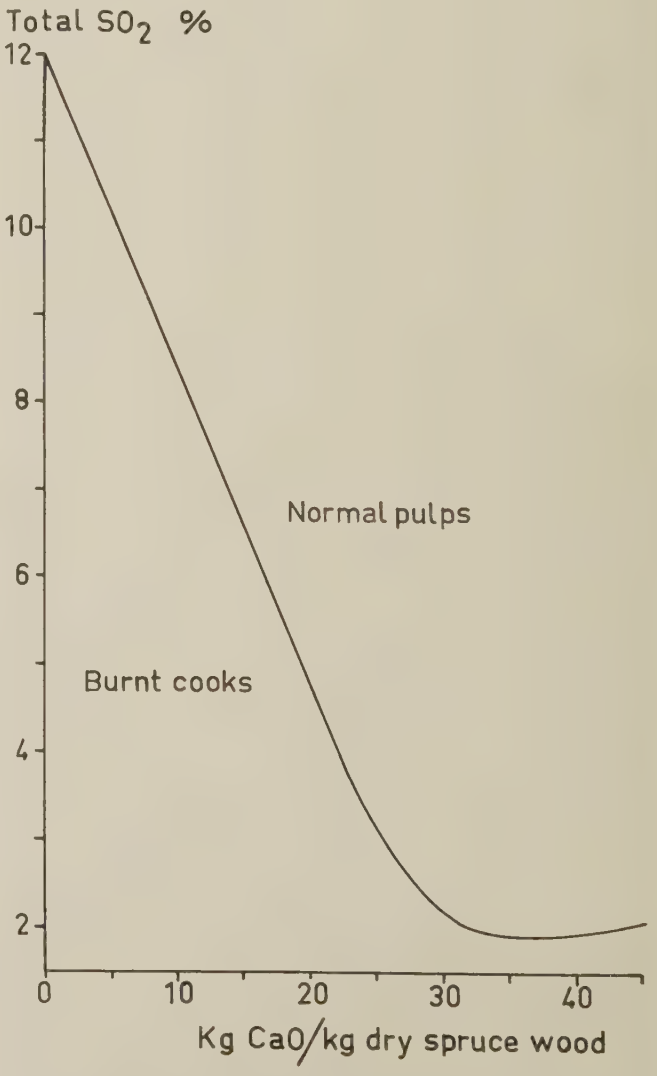

Fig. 4. Relationship between minimum SO_2 content in sulphite cooking acid and combined SO_2 (calcd. on dry wood)

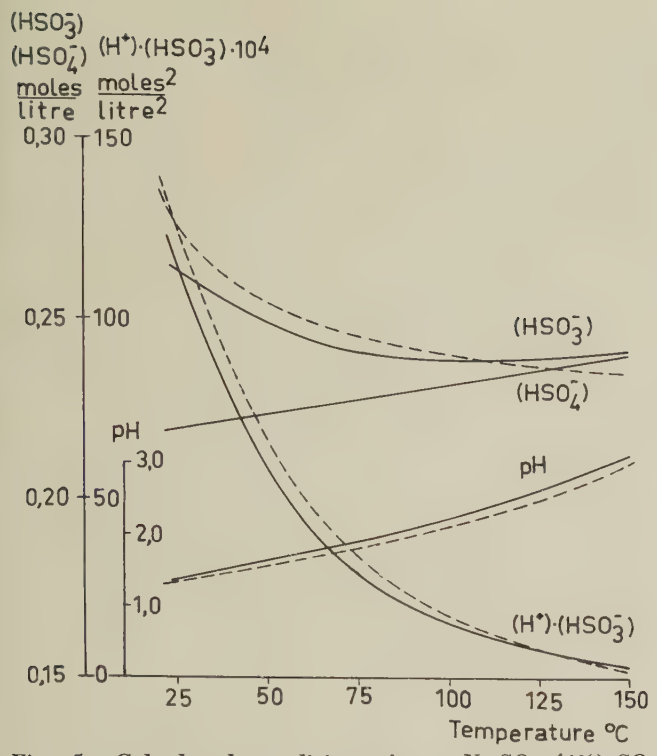

Fig. 5. Calculated conditions in a Na_2SO_4 (4%)-SO_2 (7.0%) solution (solid curves) and in an SO_2 (0.75% combined; 7.0% total) solution (dotted curves)

The possibility of such a sulfite cook depends on the equilibrium

$$H_2SO_3 + SO_4^{--} \rightleftharpoons HSO_3^- + HSO_4^-$$

It thus uses the second dissociation stage of the sulfuric acid as buffer. The SO_4^{--} in this case can be regarded as a weak base. Since the dissociation constants for both H_2SO_3 and HSO_4^- are almost the same the equilibrium constant for this reaction will be very close to 1.

Figure 5 has been prepared using the most recent results available on the dissociation constants and the temperature dependence of the dissociation constants of sulfurous acid and bisulfate ions (*11*) in order to show the concentration of the different ions as a function of the temperature for an ordinary sulfite cooking acid with 0.75% of combined SO_2 and 7% total SO_2 and for a solution containing 4% Na_2SO_4 and 7% SO_2.

It is apparent from Fig. 5 that the two cooking acids are almost identical in pH, HSO_3^--concentration, and in the product $[H^+] \cdot [HSO_3^-]$. It would thus be expected that the two acids would give very similar sulfite cooks. That this is indeed the case is shown by Table II which gives some interpolated values for cooks of paper pulps with a chlorine number of 5 and for cooks of viscose pulps with a viscosity of 30 cp. (TAPPI T-206, CCA 16). The ordinary sulfite cooking acid used in these cooks contained 0.9 and 0.8% of combined SO_2 respectively.

The agreement between calculated and experimental results is surprisingly good. According to theoretical calculations the temperature dependence of the sulfite cook should be the same for both cooking acid types. This is confirmed by the experimental results (Fig. 6). Some of the pulps obtained were beaten in a PFI mill and strength-tested according to CCA 17 (Table III).

This showed that there is no apparent difference between Na_2SO_4 pulps and CaO pulps though the former were perhaps a little more easily beaten than the standard pulps.

Table II. Sulfite Cooks with Normal Acid and Na_2SO_4-SO_2 Solution

Wood:liquor ratio 1:4

Max. temp., °C.	*Cooking acid* Na_2SO_4, %	*Combined* SO_2, %	*Total* SO_2, %	*Cooking time, min.*	*Chlorine number*	*Viscosity, cp*	*Yield, %*
135	4.0	...	9.0	25	5.0	112	51.2
135	...	0.9	9.0	55	5.0	121	51.3
145	4.0	...	9.0	25	1.6	30	44.8
145	...	0.9	9.0	37	1.2	30	44.1
140	4.0	...	7.0	310	1.4	30	44.8
140	...	0.8	7.0	260	1.5	30	44.9

Some of the viscose pulps were delignified with sodium chlorite before determination of viscosity and alkali solubility in 18% and 10% NaOH (Table IV).

No significant difference was found between pulps made with the two different types of cooking acid. Even if sulfite cooking with Na_2SO_4 cannot be justified economically except in special cases, the calculations and experiments show that soluble sulfates are to be regarded as cooking chemicals, if only indirectly. Sulfate is formed in all sulfite cooks by decomposition of the cooking acid. When soluble bases are used the sulfate will therefore contribute to the sulfonation of the lignin. In the same way some sulfate formation is to be expected in chemical recovery and will also contribute indirectly to the delignification.

The specific effect of soluble sulfates decreases in the presence of bisulfite because the equilibrium

$$H_2SO_3 + SO_4^{--} \rightleftharpoons HSO_3^- + HSO_4^-$$

is displaced to the left. This effect is still greater if the sulfite cook is done at a high pH.

In a viscose pulp cook the presence of Na_2SO_4 in a

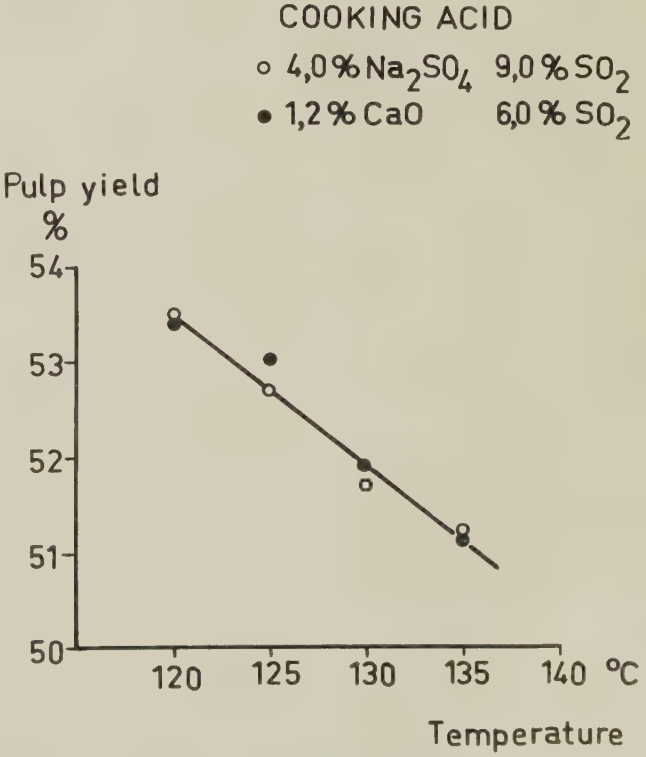

Fig. 6. Variation in pulp yield at chlorine number 5 with temperature

Table III. Strength tests

Cooking conditions: Max. temp., °C.	Base	SO_2, %	Cooking time, min.	Total yield % of m-f wood	Chlorine number	45° S.-R. (interpolated values): Beating revs., PFI	Breaking length, km.	Burst strength, kg./cm.	Tear factor	Folding number
135	4% Na_2SO_4	9	25	51.1	4.9	4750	10.0	6.9	95	4400
135	4% Na_2SO_4	9	25	51.9	4.8	4950	10.0	7.0	103	6000
120	1.2% CaO	6	510	53.3	5.1	5000	10.4	6.6	96	3600
135	1.2% CaO	6	140	51.6	4.8	4850	10.0	6.8	115	4400

normal soluble base cooking acid may have a buffering effect during the final stage of the cook and prolong the cooking time (Fig. 7).

SULFITE COOKING AT pH 4

Recently, cooking studies at a somewhat higher pH than those that have been considered, about pH 4.0 to 4.5 as measured in the cold liquor, has been carried out at the CCL. This will correspond more or less to a pure bisulfite solution. Obviously this type of sulfite cook will require a soluble base. The Magnefite process (*12*) and the Arbiso method (*13*) that have recently been described are processes of this type.

Table IV. Viscose Pulps

Maximum cooking temperature 140°C.

Cooking acid: Na_2SO_4, %	CaO, %	SO_2, %	Chlorite delignified pulps: Viscosity, cp.	α-cell yield, %	R_{18}[a], %	R_{10}, %	R_{18}–R_{10}, %
2.0	...	9	35	40.3	91.1	87.8	3.3
3.0	...	9	35	40.6	91.1	88.0	3.1
4.0	...	9	37	40.2	90.4	88.1	2.3
5.0	...	9	37	39.6	91.0	87.6	3.4
...	0.9	6	44	41.2	90.9	88.8	2.1
...	0.9	6	34	38.5	91.7	87.2	4.5

[a] Resistant cellulose in 18% NaOH (CCA 8:55).

The sulfonation of lignin at pH 4 or higher will be somewhat slower than at a lower pH (*14*), but will take place under much milder hydrolytic conditions. There is therefore less risk of lignin condensation during the sulfonation stage provided there is good impregnation with cooking acid. The hemicelluloses are hydrolysed and dissolved to a smaller extent and the cellulose degradation is slower. This applies of course in the sulfonation stage. The hydrolysis of the sulfonated lignin is also slower than at lower pH and it is therefore necessary to use a higher temperature. For a cook at pH 4, a temperature of 160°C. gives about the same cooking times as 130°C. in an ordinary cook (*15*). However, the increase in temperature increases the rate of breakdown of the cellulose chains faster than the rate of lignin release and the viscosity of this type of pulp will therefore be lower than that of a normal sulfite pulp of the same chlorine number (*15*). This is even more marked in a single-stage cook with a pH 6 cooking acid (Fig. 8). It gives a risk of a weaker pulp since the strength properties of the pulp usually fall rapidly, when the viscosity falls below a certain limit.

The tensile (Fig. 9) and the burst strength (Fig. 10) plotted as functions of the chlorine number indicate that the deterioration in strength of pH-4 pulp at chlorine numbers of less than 10 to 12 may depend partly on the viscosity. These curves also show the surprisingly high tensile and burst strength of the pH-4 pulp, almost as high as that of unbleached sulfate pulp. It should be noted that none of the pulps were dried before beating. An undried sulfate pulp after beating has a tensile of not more than 12,000 m. and a burst factor of 100. It would then be expected that the tear factor of the pH-4 pulp would be exceptionally low but as is shown in Fig. 11 this is not entirely the case. The tear factor is certainly lower than corresponding values for wet sulfate pulps which can have tear factors of up to 120, but in comparison with sulfite pulps the tear factor must be considered high. At a chlorine number of about 4 the tear factor is only about 10% below sulfate pulp values. The comparison of the strength properties is somewhat unfavorable to the pH-4 pulp since these values are for 45° S.-R. (550 S.-R. Freeness) and the tensile and burst strength maxima occur at a lower degree of beating where the tear strength has a higher value than at 45° S.-R.

Other properties of the pH-4 pulp that are worth attention are its beatability, brightness, and ease of defibration. The work required to produce a given degree of beating is roughly half of that required by a sulfate pulp. Even at yields of 58 to 60%, corresponding to a chlorine number of about 12, the pH-4 pulp is easily defibrated and gives a shive-free pulp on laboratory scale water defibration at 1.5 atm. water pressure. The brightness is more or less comparable with that of sulfite pulp and can reach values of 60 to 65% G.E. The actual value depends strongly on the chemical to wood ratio of the cooking liquor and on the chlorine

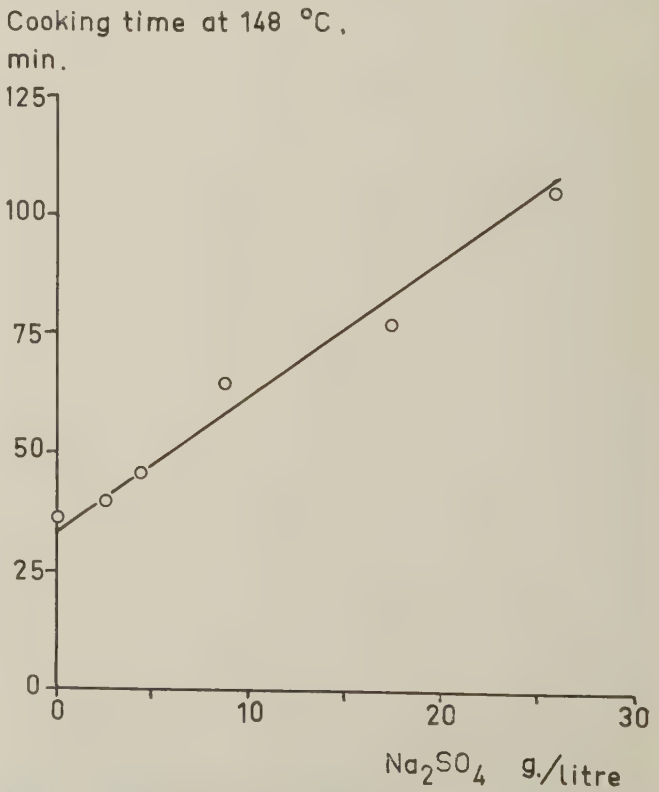

Fig. 7. Dependence of cooking time for a pulp viscosity of 30 cp. on the amount of Na_2SO_4 in a normal soluble base sulfite cooking liquor. (Courtesy Mo och Domsjö AB)

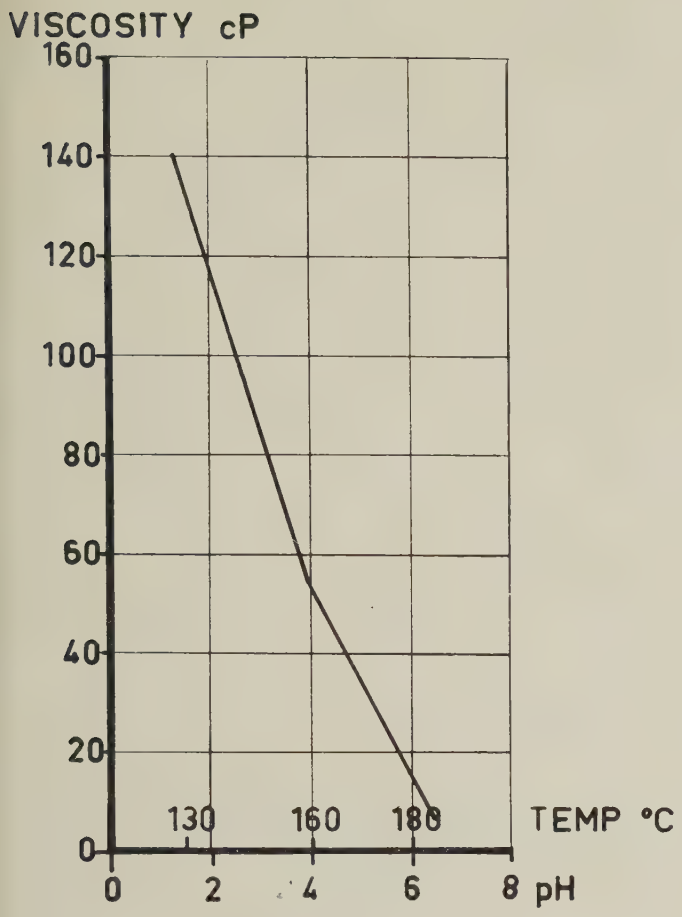

Fig. 8. Relationship of pulp viscosity at chlorine number 6 to pH of sulfite cooking liquor

number of the pulp (Fig. 12). When the $NaHSO_3$ is almost consumed there occurs a rapid fall in brightness.

The explanation of why it is possible to make pulps with high strength characteristics within a pH interval around 4 is probably that the wood fibers, especially the fibers from bruised chips and compression wood which are "acid susceptible," are not exposed to hydrolysis at this pH as in normal sulfite pulping, and thus, when beaten, do not give fiber fragments and a consequent reduction in the strength of the paper (*16*). In sulfite cooking under more neutral conditions than pH 4, the delignification is very slow relative to the degradation of the cellulose, and chemical pulps made in this pH interval have a viscosity so low that the

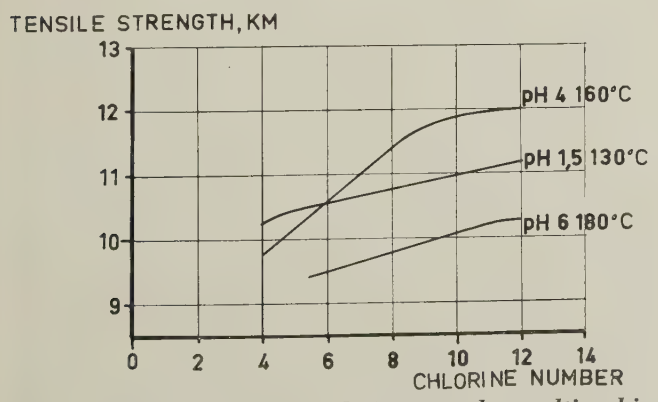

Fig. 9. Tensile strength-chlorine number reltionship after cooking with sulfite liquor of different pH values

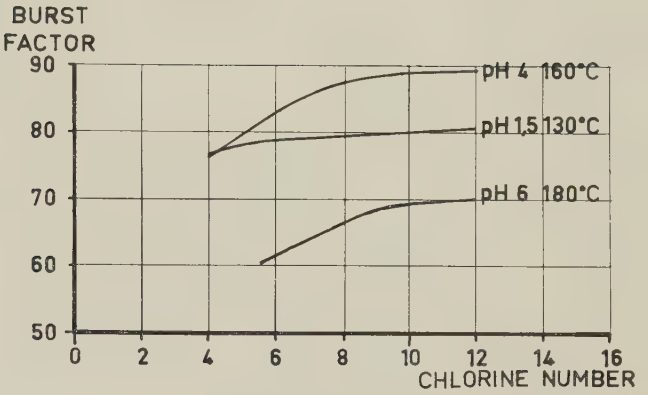

Fig. 10. Burst factor-chlorine number relationship after cooking with sulfite liquor of different pH values

strength of the paper is also low. The pH-4 pulps on the other hand have, at least at higher chlorine number, a sufficiently high viscosity to give papers with good strength.

TWO STAGE COOKS

As was indicated earlier it is sometimes advantageous to use a high pH during sulfonation of the lignin and then to carry out the hydrolysis of the lignosulfonic acids at a lower pH. The lignosulfonic acid release can then be done at a lower temperature and faster,

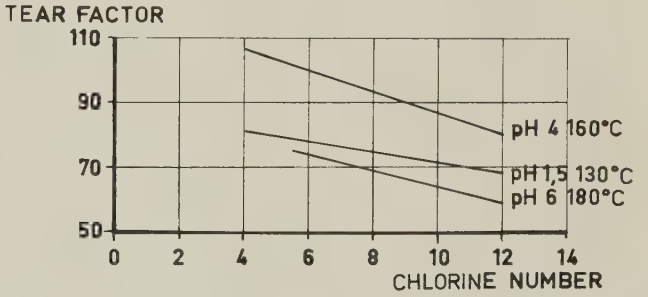

Fig. 11. Tear factor-chlorine number relationship after cooking with sulfite liquor of different pH values

and the reduction in the viscosity of the cellulose will be considerably less.

Two-stage cooking has been used on an industrial scale for many years in sulfate cooking with prehydrolysis. In the sulfite industry, however, it is of considerably more recent date. The prerequisite for the manufacture of double-cooked sulfite pulps were obtainable only after the introduction of sulfite cooking with soluble bases and the development of systems for chemicals recovery. During 1934, two-stage cooked,

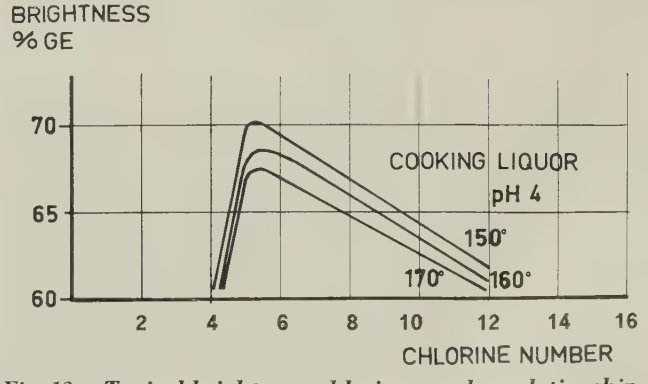

Fig. 12. Typical brightness-chlorine number relationship

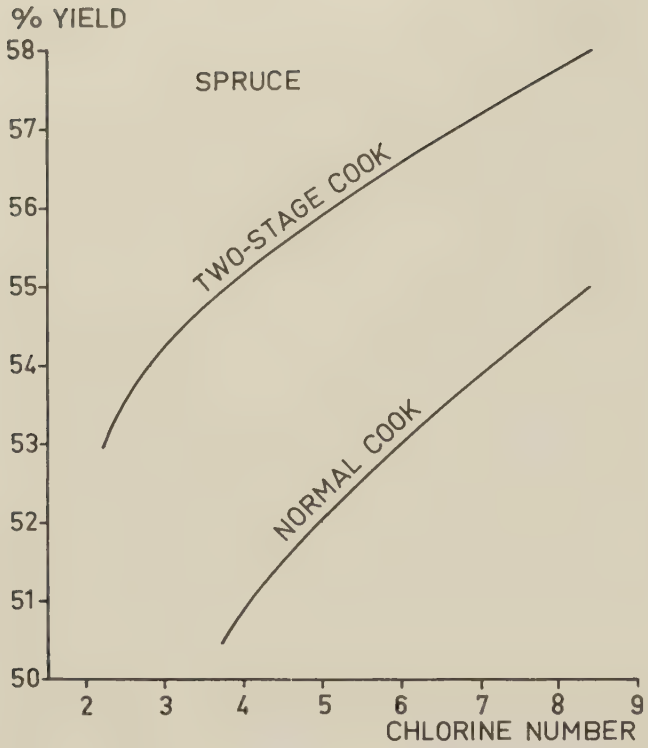

Fig. 13. Relationship of yield of unbleached pulp to chlorine uumber. (Courtesy Svenska Cellulosa AB)

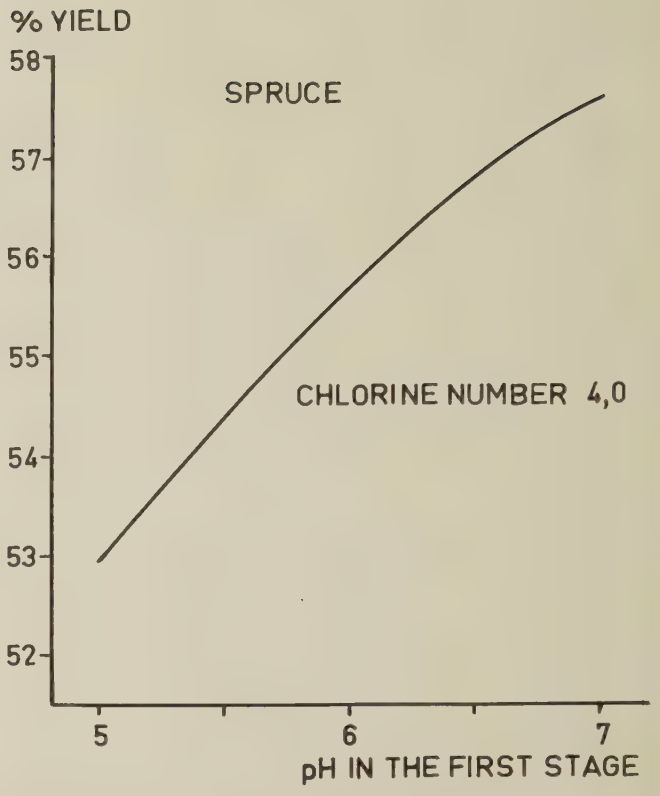

Fig. 14. Relationship of yield of unbleached pulp to pH during the first stage of the cook. Second stage as in normal sulfite cooking. (Courtesy Stora Kopparbergs Bergslags AB)

sulfite pulp was made at Lilleström in Norway according to Haglund's patent but this was too early for the process to be run economically. The first to introduce a two-stage cook seems to have been the sulfite mill at Raumo in Finland, which began to use the Sivola process in 1952. In Sweden the production of two-stage cooked, sulfite pulp was started by Söråker in 1953 and by Kramfors in 1956. Both these mills are owned by Svenska Cellulosa AB (Swedish Cellulose Company). Skutskär, (Stora Kopparbergs Bergslags AB), which changed to the use of sodium base in 1937, converted their sulfite mill to two-stage cooking in 1955. These Swedish mills all make paper pulps. At the present time Mo och Domsjö AB are about to change from calcium to sodium base at their viscose pulp mill in Alfredshem and later may change to a two-stage cook.

The following are the main advantages of the two-stage process though the order in which they are given is not necessarily that of importance.

1. Increased raw material base since even woods such as pine that contain phenolic substances, and so-called bark-damaged wood can be pulped. These types of wood can also be pulped by single-stage cooking at pH 4.

2. Higher yield under certain conditions. Tydén (*17*) has shown that the yield of two-stage cooked, sulfite pulp is considerably higher than that of ordinary sulfite pulp of the same chlorine number when the first stage is carried out with Na_2SO_3 solution (Fig. 13). This increase in yield is due to a smaller hemicellulose loss and depends on the pH at which the first stage is carried out, as is shown in Fig. 14 (based on a laboratory study at Stora Kopparberges Bergslags AB). It gives increased beatability and alters the strength properties (Figs. 15 and 16) (*17*). The higher hemicellulose content can of course be reduced in the alkaline stage of bleaching.

3. Greater flexibility in the grade of pulp obtainable. The cooking conditions in the two stages can be varied independently within wide limits and thus allow great freedom in the choice of pulp grade. It allows the production of very high hemicellulose pulps but it is of course also suitable for viscose pulps.

CONCLUSION

In this lecture there have been discussed some of the factors that make the sulfite process, using the term in its widest sense, a process that is extremely flexible both in operating conditions and in the grade of pulp obtainable. The composition and the acidity of sulfite cooking liquor can be varied within very wide limits and the process can be run in one, two, or more stages. This allows the production of a very wide range of pulp grades. The process can also be adapted to suit the raw material thus allowing the use of wood that is not suitable for ordinary sulfite cooking.

An overall view of the results described here can best be obtained if the sulfite cook is regarded from the point of view of wood chemistry.

Lignin release in the sulfite cook is regulated principally by three processes: condensation, sulfonation, and hydrolysis. To some extent these all take place simultaneously. Hemicellulose release and cellulose degradation are determined mainly by the hydrolytic conditions during the cook and are dependent on both the pH and the temperature.

The greatest difficulty in sulfite cooking with SO_2 solutions alone is to suppress the condensation reactions. As is well known the risks of condensation increase with increasing hydrogen ion concentration and temperature. Since the risk of condensation

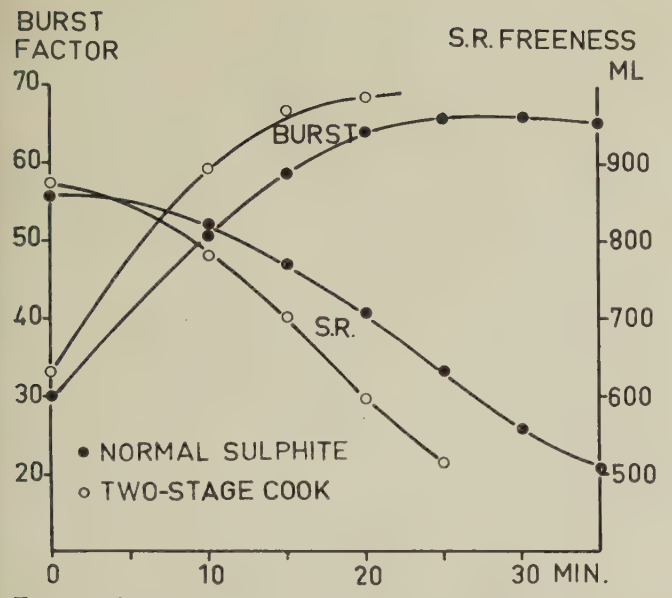

Fig. 15. Relationship of burst factor and drainage resistance to beating time. Valley beater; chlorine number 7.0 (cf. Fig. 13). (Courtesy Svenska Cellulosa AB)

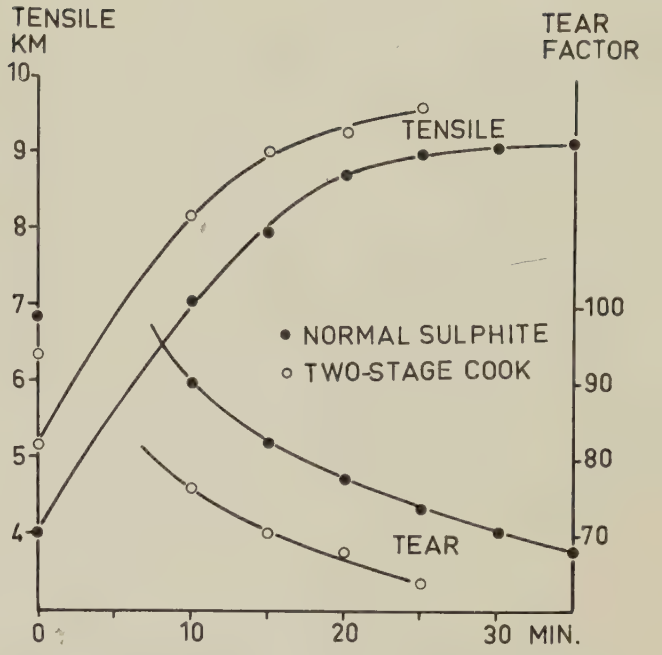

Fig. 16. Relationship of tensile strength and tear factor to beating time. Valley beater; chlorine number 7.0 (cf. Fig. 13). (Courtesy Svenska Cellulosa AB)

decreases as the degree of sulfonation increases it is necessary to sulfonate the lignin to the required extent under conditions such that condensation is of minor importance. It has been shown that this requirement can be satisfied in a sulfite cook using only SO_2 solution (Figs. 1 and 2). This demands, however, a high SO_2 concentration to speed up the sulfonation of the lignin, and a relatively low temperature to suppress the condensation. Once the sulfonation has passed a certain level there is no risk of condensation in carrying out the hydrolysis at a higher temperature as in ordinary sulfite cooking (Fig. 3). Lignin release in this case occurs faster than in the presence of base, presumably because the hydrolysis of the lignosulfonic acids is determined by the hydrogen ion concentration in the solid phase. Lignin condensation is normally not a problem of any importance in ordinary sulfite cooking or with cooking liquors with a higher pH. This assumes of course that the chips, before pulping, are completely impregnated with the cooking liquor (*18*, *19*) and that there is no abnormal degradation of the cooking acid. The reactions of the lignin and the carbohydrate during a sulfite cook are determined largely by the bisulfite ion concentration, the product $[H^+]\cdot[HSO_3^-]$, and by the pH at the cooking temperature. By choosing a suitable sodium sulfate concentration in a Na_2SO_4–SO_2 cooking acid, these factors can be made almost the same for any temperature as those in an ordinary sulfite cooking acid (Fig. 5). It is therefore only to be expected that very similar grades both of paper (Fig. 6, Table III) and viscose pulps (Table IV) can be obtained with both types of cooking acid.

A sulfite cook with an acid at a pH, of 4 in the cold, or higher, differs from ordinary sulfite cooking mainly in the slower hydrolysis of the lignosulfonic acids and in the resultant slower lignin release. It is therefore necessary to use a higher temperature if the cook is to be done in about the same time as an ordinary sulfite cook. The higher cooking temperature, however, increases the rate of cellulose degradation. Thus if a comparison is made of different pulps cooked to the same chlorine number with cooking acids of pH from 1.5 (normal sulfite) to 6, it is found that the viscosity falls as the pH of the cooking acid rises (Fig. 8). Chemical pulps cooked in a single stage at pH 6 therefore show very low strength properties. Sulfite pulps cooked with a pH 4 cooking acid to a chlorine number of 10 to 12, where the pulp is easily defibrated, will have a sufficiently high viscosity to give a paper with excellent strength properties (Figs. 9, 10, 11). The reason why ordinary sulfite pulps in spite of a still higher viscosity for a given chlorine number give papers with lower strength is probably the occurrence of so-called acid susceptible wood, which gives rise to a considerable reduction in fiber length on beating. At a pH of about 4 this typical fiber damage does not seem to develop to the same extent.

From this discussion it will be clear that it may be advantageous to run a sulfite cook in two stages. In the first stage the lignin is sulfonated at a relatively high pH, between 4 and 10 for instance, where the lignin condensation is of no importance and the hydrolytic attack on the carbohydrates is very small. The cook is then completed in a second stage by lignin release at a lower pH, for instance between 1 and 4. In this way pulps with a 8 to 10% higher yield can be obtained compared to normal sulfite pulping (Figs. 13 and 14).

SUMMARY

The sulfite cooking process has been discussed in the light of investigations made at the Central Laboratory of the Swedish Cellulose Industry (CCL) in Stockholm. The results show that sulfite cooking can be done with SO_2 solution alone in the absence of base. With a maximum digester pressure of 15 atm. (220 p.s.i.g.) the cooking time can be 5 to 10 hr. depending mainly on sulfonation temperature. Lignin release under these conditions is faster than in sulfite cooking with bases. The characteristics of the pulp obtained are comparable with those of corresponding pulps prepared by con-

ventional sulfite cooks. SO_2-cooked pulps are easily defibrated without mechanical aid at a chlorine number of 10 to 12 corresponding to 58 to 60% yield.

A sulfite cook with Na_2SO_4–SO_2 solution is in principle equivalent to an ordinary sulfite cook since the bisulfite and hydrogen ion concentrations can be made almost identical in the two cases. Cooking experiments with both paper pulps and viscose pulps showed no detectable differences in quality between pulps prepared by cooking with Na_2SO_4–SO_2 solution and by ordinary sulfite cooking.

Sulfite cooks on spruce made with a $NaHSO_3$ solution of pH about 4 at room temperature give chemical pulps, that is, pulps not requiring mechanical defibration, in yields of 58 to 60% with excellent strength properties, approaching those of sulfate pulp.

Two-stage, sulfite cooking has many interesting advantages.

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A Practical Approach to Utilization of Solids from Deinking Mill Effluent

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Chemical and physical characteristics of deinking mill sludge are reported. Possible utilization of the modified sludge as filler for paper and rubber goods and as building material is discussed. Results of electrophoretic and flotation experiments are given.

Since the establishment of the paper industry in the Kalamazoo area, the deinking mills discharged their effluent into rivers and streams. This practice continued until, as a result of steadily growing volume of production and continuously increasing population, the industrial and municipal load became too large. Presently, the deinking mills are making strenuous efforts to improve the condition of the Kalamazoo River. This paper deals with development work designed to utilize the solids concentrated from the effluent of deinking mills.

As early as 1944 the National Council for Stream Improvement established an industrial fellowship at the Mellon Institute (*1*) to develop satisfactory methods for the disposal and utilization of effluents from the manufacture of pulp, paper, and paperboard. Extensive work was carried out on the removal of solids and reduction of biochemical oxygen demand (B.O.D.). In 1946 a research laboratory was set up at Kalamazoo College, Kalamazoo, Mich., headed by P. F. Morgan. It was found that by a combination of sedimentation and treatment with coagulants or sedimentation and aeration, the pollution load of the effluent from deinking mills could be reduced considerably (*2*). A pilot plant was constructed at The Michigan Paper Co. at Plainwell to further these studies (*3*).

Five deinking mills in the Kalamazoo Valley, namely, Allied Paper Mills, Kalamazoo Paper Co., Michigan Paper Co., Rex Paper Co., and St. Regis Paper Co., together with Watervliet Paper Co. in Watervliet, Mich., formed a nonprofit corporation under the name of Kalamazoo River Improvement Co. This company financed and constructed a disposal plant at Plainwell, Mich., to determine the feasibility of the treatment on a commercial basis by sedimentation and aeration (*4*).

The plant started operation in September, 1950, under the direction of A. J. Palladino of the National Council for Stream Improvement. Operation of this disposal plant for an adequate period of time showed that sedimentation in a specially designed tank gives an effluent of greatly improved quality. This method, however, created a new problem dealing with the disposal of large quantities of settled solids removed from the bottom of the tanks in the form of sludge.

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Table I. Results of Sedimentation

	Paper Mill Effluent (%)	*Sludge Obtained (%)*
Concentration of dissolved and suspended solids	0.372	12.0
Volatile portion of above.	46.0	39.0
Ash portion of above	54.0	61.0
Concentration of suspended solids	0.244	...
Volatile portion of above	32.0	...
Ash portion of above	68.0	...

To cope with this situation, the Kalamazoo River Improvement Co. established a research project at Western Michigan University in July, 1951, in order to explore possibilities for the utilization of the sludge discharged from the disposal plant.

A search of the literature showed that only limited information was available concerning the physical and chemical properties, as well as attempts of utilization of solids from deinking mill effluent.

Table I, as reported by Palladino (*5*), shows some characteristics of the effluent as well as of the sludge obtained from sedimentation. The composition of the solids removed in the deinking process varies greatly from mill to mill and is determined by the waste paper used. C. C. Irving (*6*) reported that the solids contained between 50 and 75% clay. A typical analysis for low volatile deinking solids was given by Morgan (*7*) as 35.7% volatile matter at 700°C., 27.1% silicon dioxide, 24.7% oxides of trivalent ions, 10.5% calcium oxide, and 1.4% magnesium oxide.

A sample of sludge was sent to a commercial laboratory for proximate analysis to determine heating value and fusion temperature of the ash. Also, a manufacturer of steam generating equipment interested in problems of the paper industry made an ultimate analysis of sludge solids. The results of these analyses may be seen in Tables II and III.

Irving (*6*) proposed several possible uses for deinking solids. These suggestions were:

1. The use in the manufacture of dark colored products in lined boards.
2. The recovery of clay by ignition.
3. The use as a filler for fiberboard and other heavy lined building materials.
4. The use with binding materials in the manufacture of molded articles.

EXPERIMENTAL STUDIES OF SLUDGE PROPERTIES

Samples of sludge obtained from the settling tank of the Plainwell disposal plant (*4*) were used to study the properties of material under investigation.

Table II. Proximate Analysis of Deinking Sludge Solids

	As received	*Dry basis*
Moisture, %	2.40	...
Volatile matter, %	31.16	31.93
Fixed carbon, %	2.74	2.80
Ash, %	63.70	65.27
Total	100.00	100.00
Sulfur, %	0.10	0.10
B.t.u.	1786	1830
B.t.u. (moisture and ash free)	...	5269
Fusing temperature of ash	...	2660°F.

Table III. Analysis of Deinking Sludge

	Sludge pellets		*Powdered sludge*	
	Oven drying method, %	*Titration method, %*	*Oven drying method, %*	*Titration method, %*
Moisture	2.4	4.1	1.0	2.7
	Ultimate Analysis (Dry Basis)			
Carbon	16.7	17.0	16.4	16.6
Hydrogen	3.0	2.8	2.9	2.8
Sulfur	0.4	0.4	0.1	0.1
Oxygen-nitrogen	22.7	22.7	23.0	21.9
Ash	57.2	58.2	57.6	58.6
Cellulose[a]	37.5	38.2	36.9	37.3
B.t.u.	2750	2800	2770	2820
	Analysis of Ash, %			
Si as Sio_2	46.4		46.5	
Al as Al_2O_3	40.6		41.2	
Fe as Fe_2O_3	1.5		1.4	
Ti as TiO_2	1.5		1.6	
Ca as CaO	7.4		6.2	
Mg as MgO	0.9		1.1	
Na as Na_2O	0.3		0.3	
K as K_2O	Nil		Nil	
S as SO_3	0.3		0.3	
P as P_2O_5	0.8		0.6	
Ignition loss at 900°F.	0.1		0.3	
Undetermined	0.2		0.5	
Total	100.0		100.0	

[a] Calculated from carbon value, likely to be high.

The sludge was gray in color, had a total solids content of from 7 to 16%, felt fibrous to the touch, and was extremely viscous. Rheological studies made by means of a Brookfield viscometer showed that the sludge was thixotropic and that the viscosity increased greatly with increasing solids content. Figure 1 represents the results of those tests.

Preliminary attempts to reduce the viscosity of sludge with dispersing agents like tetrasodium pyro-

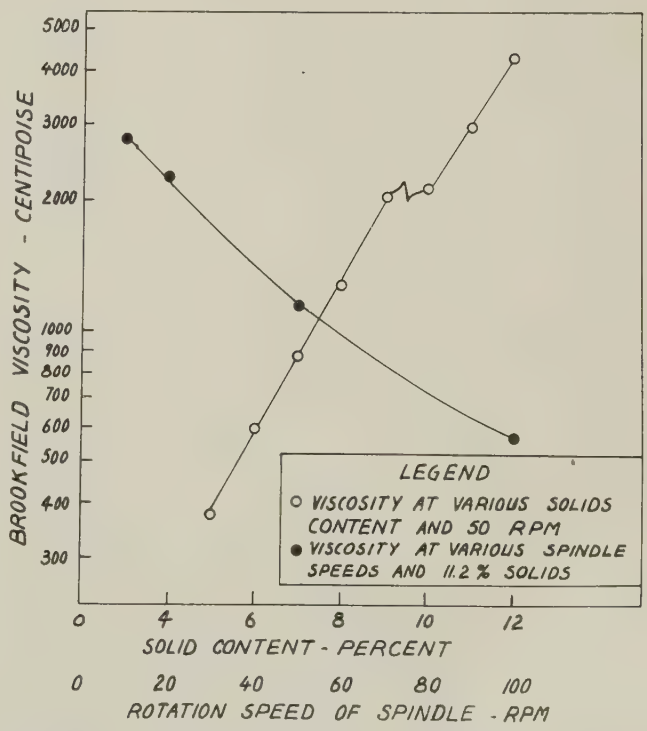

Fig. 1. Brookfield viscosity of deinking sludge

Table IV. Results of Incineration of Deinking Sludge at Various Temperatures

Incineration temperature, °F.	Photovolt brightness, %	Color, visual
500	13.5	Brown
700	32.5	Gray
900	63.5	White
1100	71.0	White
1300	80.0	White
1500	81.5	White
1700	82.0	White

phosphate and others showed no significant decrease of viscosity. In an endeavor to find the reasons for this behavior, Drexel's (*8*) experimental work showed that the mineral solids of the sludge were in completely deflocculated condition. Furthermore, removal of fibers from the sludge gave a slurry of greatly reduced viscosity. For example, removal of fiber by screening through a 325-mesh sieve, at 10% sludge solids, caused a reduction of Brookfield viscosity at a spindle speed of 10 r.p.m. from 2000 to 40 centipoise.

Ash determinations at 1700°F. in an electric muffle furnace showed that the sludge contained 47.1% to 61.0% ash. The color of the incinerated product was white. It was also found that the brightness, i.e., per cent reflectance at 457 mμ effective wavelength, and color of the ash varied with incineration temperature, highest Photovolt brightness being recorded at the highest temperature. Table IV shows the results of incineration of dried sludge. By pulverizing sludge before incineration, brightnesses as high as 86.3% were obtained at 1700°F.

Studies of particle size distribution of the sludge showed that the mineral content passed through a 200-mesh screen, and that a considerable quantity of fiber was retained on the screen. By means of a Bauer-McNett fiber classifier it was discovered that from 3.8 to 16.0% of the sludge solids (dry basis) was fiber retained by a 200-mesh screen. Various samples showed that 2.8 to 62.8% of the fibrous portion was retained by a 65-mesh screen and could be considered of potential use in the manufacture of paper.

Deinking sludge held water tenaciously. Vacuum filtration or lagooning of sludge produced a concentrate

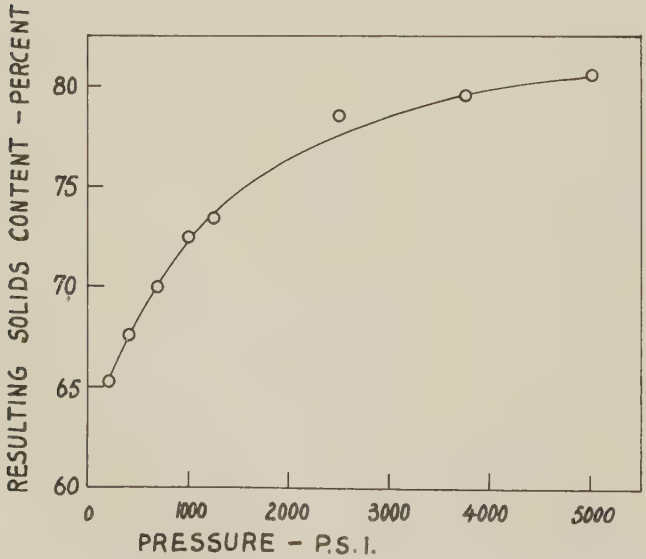

Fig. 2. Concentration obtained by application of pressure on vacuum filtered sludge

of about 25 to 40% solids (*5, 9, 10*). Tests run by means of a hydraulic press showed that more water could be removed by this method. Vacuum filtered sludge at 27% solids was submitted to various pressures for 30 min. A pressure of 200 p.s.i. produced a product of 65.2% solids, thus removing about 80% of the water. At a pressure of 2000 p.s.i., the solids concentration reached 80.5% with a corresponding water removal of 91%. Figure 2 illustrates the results of these experiments.

Tests were made to determine the concentration of preservative necessary to prevent decomposition of the sludge. Over a 3-month period these tests indicated that about 15.5 lb. of commercial formaldehyde or 8 lb. of sodium pentachlorophenate per ton of sludge solids were the minimum quantities needed for preservation at room temperature. The odor imparted to the sludge by the preservatives limited its usefulness.

APPROACHES TO SLUDGE UTILIZATION

Two approaches were used in development work on the utilization of solids settled from deinking mill effluent. The first and more desirable approach was to convert these solids into products that could be reused in papermaking, thereby eliminating marketing expenses and transportation costs. The possibility existed that the Kalamazoo paper industry could not use all of the modified solids; consequently, a second approach was used, which consisted of studying other industries as potential consumers of modified sludge solids to give better opportunities for the utilization of all of the solids removed from deinking mill effluent.

In pursuing these two approaches, extensive work was carried out in the fields of industrial fillers, building materials, and the reclamation of clay.

INDUSTRIAL FILLERS

The high mineral content of the sludge suggested its use as a filler for the paper industry, rubber industry, and other manufacturers. Work in this field led to the development of two types of products. The first product was gray in color and was produced by drying and powdering of sludge. The second product was a high white pigment produced by calcining the powdered sludge.

Table V. Comparison of Calcined Sludge and Commercial Coating and Filler Pigments

Range of particle size, microns	Calcined sludge	Commercial calcined clay 1	Commercial calcined clay 2	Coating clay	Filler clay
	Particle Size Distribution %				
0–1/4	Trace	Trace	Trace	15	1
1/4–1/2	2	4	2	29	3
1/2–1	11	24	24	35	8
1–2	17	40	21	15	13
2–5	19	27	24	5	31
5–10	19	4	18	1	25
Above 10	32	1	11	1	19
	Evaluation as a Coating Pigment				
Smoothness, %	0.	...	5.	...	...
Standard Wax-Dennison	0.	...	5.	...	..
Gloss-Ingersoll, %	34.2	...	37.5	...	...
Block brightness, %	83.9	90.0	90.1	...	...

Upon testing the initially obtained calcined material, it was found to be too coarse and too abrasive to be used by the paper industry as a coating and filling pigment. Table V compares the characteristics of the originally produced calcined sludge with commercial products, namely two calcined clays, a filler clay, and a coating clay.

Experiments were made to reduce the particle size in terms of equivalent spherical diameter. Tests showed that sludge pulverized in a laboratory hammer mill before calcining did not form fused agglomerates but remained in pulverized form after incineration. The particle size was finer and brightness was higher than when pulverized after calcination. Wet screening proved that all of the calcined product was finer than 100 mesh. The particle size distribution of this material was found to be in the range of coarse filler clays and the brightness of this product ranged up to 86.3%.

The effect of ball milling on the reduction of particle size was studies (*11*, *12*, *13*). One-pound samples of the calcined material prescreened through a 325-mesh sieve were ball-milled in both dry and wet (40% solids) conditions for 3, 6, and 24-hr. periods. The mill used rotated at 58 r.p.m. and at a periperal speed of 126.7 f.p.m. The grinding medium used was tubular shaped Borundum in a quantity of 12 lb. The Borundum tubes were 0.8125 in. in diameter as well as length and had a density of 228 lb. per cu. ft. Particle size determinations were made by sedimentation (*14*, *15*). Table VI expresses results of these tests.

Table VI. Comparison of Results of Wet and Dry Ball Milling of Calcined Sludge

	Particle size in microns					
	Above 10, %	*10–5, %*	*5–2, %*	*2–1, %*	*1–0.5, %*	*Below 0.5, %*
Starting material	20.0	26.0	29.0	15.0	10.0	Trace
Dry ball-milled, 3 hr.	9.0	16.0	31.0	25.0	14.0	5.0
Wet ball-milled, 3 hr.	6.0	19.0	36.0	23.0	15.0	1.0
Dry ball-milled, 6 hr.	7.5	13.0	29.0	25.5	15.0	9.0
Wet ball-milled, 6 hr.	3.0	12.5	37.0	29.0	14.0	3.0
Dry ball-milled, 24 hr.	5.0	13.0	28.0	25.0	22.0	7.0
Wet ball-milled, 24 hr.	1.0	6.0	29.0	31.0	24.0	9.0

As may be seen from the data given in Table VI, wet ball-milling was more effective in the reduction of the particle size than dry ball-milling. This was attributed to the fact that calcined material in dry state caked onto the grinding medium. All of the grinding tests reduced the particle size of calcined sludge to the range of filler clays and commercial calcined clays used in papermaking. However, the particle size obtained by both dry and wet-milling was coarser than commercial coating clays.

Ball-milling proved to be beneficial in another respect. The abrasiveness was substantially decreased. Dry ball-milling for 6 hr. reduced the abrasion by about 20.4% while the 24-hr. milling test caused a 28.6% reduction. Wet grinding was even more efficient in lowering the abrasive characteristics of calcined deinking sludge. Table VII presents the abrasive characteristics of various forms of modified deinking sludge and the reduction of abrasiveness caused by ball-milling.

Another technique used to obtain calcined products with a larger portion of fine particles was fractional sedimentation. Calculations indicated that particles of 10 μ in size settle at a rate of about 0.009 cm. per sec. at laboratory temperatures (*15*). A pound of powdered calcined sludge, previously passed through a 325-mesh sieve was converted into a water slurry, dispersed with tetrasodium pyrophosphate and allowed to settle for 55 min. After this period of time, the water-solids mixture from the surface to 30 cm. below the surface was siphoned off. Realizing that a considerable portion of finer particles was still with the coarse fraction due to the particles' position within the slurry at the start of sedimentation, the settled fraction was re-diluted and subjected to the above procedure twice more. The fractionation yielded a separation into two, practically equal fractions. The resulting particle size distribution of the fine portion was in the range obtained by dry ball-milling. Table VIII shows the results of these tests. Work on the utilization of deinking solids as filler pigment was not confined to the paper industry. A manufacturer of rubber products and a manufacturer of asphalt tile commented that the fillers were useful in the manufacture of their products. These conclusions were based on extensive experimental work carried out in their laboratories.

Table VII. Comparison of the Abrasive Characteristics of Modified Deinking Sludge and Commercial Clays

	Calcining temperature, °F.	Wire loss, mg.	
		10,000 Strokes	*2000 Strokes*
Commercial clay	0	52	...
Commercial calcined clay	...	399	...
Sludge −200 mesh	0	210	...
Sludge	700	91	...
Sludge	900	253	...
Sludge	1100	416	...
Sludge	1300	258	...
Sludge	1500	830	...
Sludge	1700	1058	...
Sludge −325 mesh	1700	...	220
Sludge ball-milled dry, 6 hr.	1700	785	175
Sludge ball-milled dry, 24 hr.	1700	...	157
Sludge ball-milled wet, 24 hr.	1700	521[a]	...

[a] The pump on the abrasion tester was changed resulting in a faster pumping rate of the slurry. The rate of wire loss on the laboratory standard clay changed from 50 to 70 mg.

FUEL COSTS OF DRYING AND CALCINING

Favorable reports from the laboratories of the rubber and asphalt tile industries led to theoretical calculations on the cost of fuels needed for drying and calcining sludge.

Heat requirements were calculated from material and heat balances. Operating conditions and data for rotary driers and calcining equipment were found in Perry's "Chemical Engineers' Handbook" (*16*) and Stephenson's "Pulp and Paper Manufacture" (*17*). Specific heat values for solid materials were taken from Hougen and Watson (*18*), while the molar specific heats of the various component gases were obtained from a graph prepared by the Chemical Engineering

Department at the Massachusetts Institute of Technology. Thermodynamic properties for water and water vapor were found in Keenan and Keyes steam tables (*19*).

Table VIII. Results Obtained by Fractionation of Calcined Sludge

	Particle size in microns					
	Above 10, %	*10–5, %*	*5–2, %*	*2–1, %*	*1–0.5, %*	*Below 0.5, %*
Starting material	20.0	26.0	29.0	15.0	10.0	Trace
Fine fraction	2.0	26.0	26.0	32.0	12.0	2.0
Coarse fraction	38.0	26.0	18.0	13.0	5.0	Trace

Cost of fuel delivered in Kalamazoo, Mich., and heating values were obtained from local distributors of coal, oil, and gas. The heating value of dried sludge used in calculations for calcination was 1830 B.t.u. per pound.

Cost figures were developed for several concentrations of sludge charge to the drier and to the kiln. The results indicated that it is more economical to calcine than to dry sludge, provided that the starting material is above 40% solids. The results of these calculations may be seen in Table IX.

Building Material

Development work on the utilization of deinking sludge in the field of building materials began by adding cement to sludge. Mixtures containing 12.6% of normal cement were prepared with sludge solids and, for comparison purposes, with sand. The samples were cured at room temperature for 7 days and successively for 21 days at 100% and 50% R.H., respectively. After the curing period, the sludge-cement mixture shrank to 61.5% of its original volume, while the volume of the sand-cement mixture remained constant. The density of the sludge-cement mixture was 50.5 lb. per cu. ft. as compared to 111.0 lb. per cu. ft. in the case of the concrete-containing sand.

Table IX. Heat Requirements and Cost to Dry Sludge as Well as to Dry and Calcine Sludge Per Ton of Product

Solids content of sludge, %	*Heat requirement, B.t.u.*	*Coal, $*	*Bunker "C" oil, $*	*Industrial "200" oil, $*	*Gas, $*
	Dried Sludge (Based on a 55% Thermal Efficiency)				
30	12,000,000	3.97	6.70	6.94	10.20
40	7,600,000	2.52	4.25	4.40	6.48
50	5,140,000	1.70	2.88	2.98	4.37
60	3,500,000	1.16	1.96	2.03	2.99
	Calcined Sludge (Based on a 65% Thermal Efficiency)				
30	13,500,000	4.47	7.67	7.82	11.50
40	7,620,000	2.52	4.27	4.44	6.52
50	4,090,000	1.36	2.30	2.39	3.53
60	1,740,000	0.58	0.98	1.02	1.52

To determine which cement to sludge ratio would eliminate shrinkage and which ratio would yield the lowest density, experiments were carried out with increasing quantities of cement. At 70% cement content the tendency of sludge solids to cause shrinkage was eliminated. A minimum density of 41.5 lb. per cu. ft. was recorded at 40% cement content. Figure 3 illustrates the results of these tests.

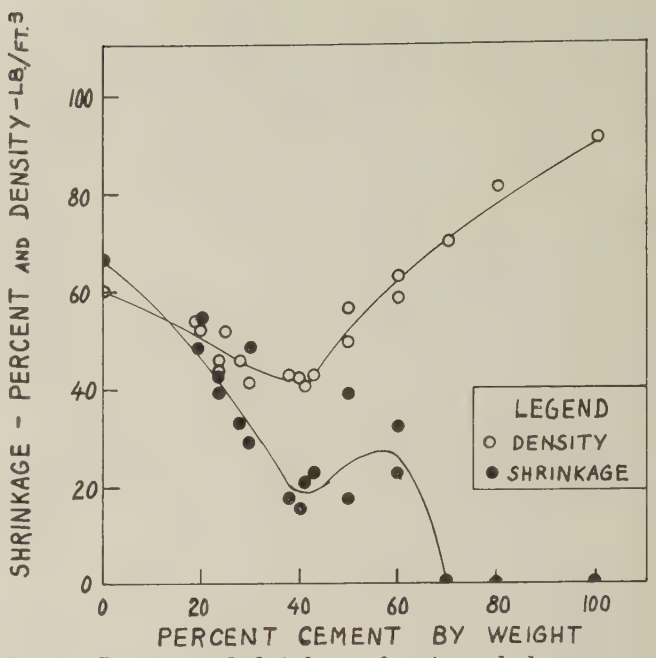

Fig. 3. Density and shrinkage of various sludge-cement mixtures

Specimens at the lowest densities could be sawed without difficulties and could be nailed. Due to the structure of the samples, they exhibited low compressive strength.

The sludge-cement mixtures were tested for water absorption by immersion. The tests showed that the mixtures absorbed water at a rapid rate during the first 20 min. after which time the rate of water absorption decreased considerably. A test cylinder containing 43.2% cement absorbed 92.2 g. of water per 100 g. of specimen during the first 20 min., while at the end of 1900 min. 99.5 g. of water were absorbed by the specimens.

To reduce the density of the sludge-cement mixture further, a rosin soap foaming agent was added in the amount of 0.5 and 0.1%, based on the weight of the solids. Two cement-sludge mixtures containing 23.0 and 39.8% cement were studied. At the lower cement ratio there was an increase in both shrinkage and density. At the higher cement ratio with the use of 0.5% foaming agent, the shrinkage remained about the same and the density was decreased 16.5% from that of a cylinder made with no foaming agent. One tenth of 1% foaming agent caused an increased shrinkage, but the density decreased about 26.1%. Table X compares the shrinkage and density of cylinders made with and without the use of foaming agent.

In order to determine potential use of deinking mill sludge in the manufacture of gypsum board, mixtures of sludge and gypsum from 100 to 0% gypsum content were prepared with the addition of 0.15% of a rosin soap foaming agent. Other materials used, to follow the procedures of manufacturers of gypsum board, were hydrated calcium sulfate and potassium sulfate. These experimental mixtures were dried at 120°F. Results

indicated that up to 25% dry powdered deinking sludge could be used without causing excessive shrinkage problems or appreciable changes in density. Table XI gives the results of these experiments.

LIGHTWEIGHT AGGREGATES

The constantly increasing demand for lightweight aggregates caused an investigation of that field, as a potential outlet for modified deinking mill sludge.

Table X. The Effect of Foaming Agent on Sludge-Cement Mixtures

Cement-sludge mixtures, total solids, %	*Foaming agent, total needs, %*	*Shrinkage upon curing, %*	*Density after curing, lb./cu. ft.*
23.2	0.0	48.0	43.5
23.0	0.5	59.5	49.7
40.0	0.0	15.2	41.8
41.1	0.1	22.7	30.9
39.8	0.5	15.5	34.9

Lightweight aggregates and lightweight concretes have many advantages. Some of these advantages are (*20*):

1. Reducing the dead load of concrete structures.
2. Savings in construction costs due to the need of less structural steel.
3. Good acoustical and insulating properties.
4. Less labor and handling and transportation needed per volume unit.
5. Easy sawing and nailing characteristics.

Because of these properties, lightweight aggregates are in great demand. It was estimated in 1950 that only 35 to 40% of the demand for these materials was satisfied (*21*).

Clays, shales, and similar materials are used to produce lightweight aggregates by exposing them to high temperatures, causing them to bloat (*20, 21, 22*). Two conditions are necessary for adequate bloating, namely, pyroplastic state of the raw material at the bloating temperature and simultaneous evolution of gas (*22*). If these two conditions are met, a product of cellular structure is produced which shows a substantial reduction in density. Lightweight aggregates from bloated clays have unit weights from 40 to 60 lb. per cu. ft.

Table XI. Characteristics of Sludge-Gypsum Mixtures

Gypsum, %	100.0	75.0	50.0	25.0	0.0
Dry sludge, %	0.0	25.0	50.0	75.0	100.0
Density, lb./cu. ft.	40.1	40.5	34.3	43.4	39.3
Shrinkage, %	3.7[a]	3.1	20.5	58.7	65.3

[a] Volume increased.

Since initial experiments showed that deinking sludge alone did not bloat at temperatures up to 2500°F., the use of admixtures was investigated. This technique was used successfully by the Bureau of Mines to cause nonbloating clays to bloat (*22*). Iron salts, alkalies, and alkali-earth compounds were found to act as fluxes thus reducing the fusion temperature (*23*). Sludge and various mixtures of iron sulfide, iron sulfite, sodium carbonate, aluminum powder, and charcoal in different concentrations and combinations were studied. Pellets were made from these mixtures and subjected to temperatures in the range from 2100°F. to 2400°F., for 15 min. in a gas furnace. The only evidence of bloating occurred when sludge containing 30% cement came in contact with the overheated iron grate at a furnace temperature of 2200°F. Table XII shows the results of these tests.

Table XII. Results of Admixtures on the Bloating Characteristics of Deinking Sludge

Admixtures to sludge	*Temperature, °F.*	*Results, visual*	*Bulking density, lb./cu. ft.*
None	2300	Not bloated	...
None	2400	Not bloated	93.6
Charcoal 20%	2300	Not bloated	45.5
Charcoal 20%	2400	Not bloated	66.5
Cement 30%	2100	Not bloated	...
Cement 30%	2200	Not bloated	65.3
Cement 30%	2300	Vitrified[a]	...
FeS_2 2.5%	2300	Not bloated	75.7
FeS_2 2.5%	2400	Not bloated	99.5
FeS_2 6.5%	2300	Not bloated	90.5
FeS_2 6.5%	2400	Not bloated	143.3
$FeSO_4$ 6%	2300	Not bloated	88.7
$FeSO_4$ 6%	2400	Not bloated	116.7
Aluminum powder 0.1%	2300	Not bloated	65.7
Aluminum powder 0.1%	2400	Not bloated	100.0
Cement 30% + $FeSO_4$ 6.8%	2100	Not bloated	80.2
Cement 30% + $FeSO_4$ 6.8%	2150	Not bloated	...
Cement 30% + $FeSO_4$ 6.8%	2200	Melted	...
Na_2CO_3 2% + FeS_2 2%	2300	Not bloated	...
Na_2CO_3 2% + FeS_2 2%	2400	Not bloated	117.0

[a] The vitrified specimen had a glassy surface. Part of this sample came in contact with the iron grate of the furnace and bloated.

Only in two cases did the admixtures produce a vitrified specimen. Since, according to Miller (*21*), vitrification and the pyroplastic state (*22*) has to take place before bloating can be accomplished, higher temperatures were applied.

The gas furnace had an upper zone designed for a maximum temperature of 2400°F., and a lower zone or fire box where gases were burned at approximately 2800°F.

Sludge introduced into the lower zone showed bloating and was white in color, cellular in structure, and glassy in its surface. The bloated particles floated in water. Tests proved that bloating took place with either wet or dry sludge. The apparent bulking density of the aggregates ranged from 15.2 to 86.2 lb. per cu. ft. depending on the size produced.

Two other types of aggregates were developed, namely, dried sludge pellets of low density and low strength, and calcined sludge aggregates of fairly low density and superior strength. Apparent bulking densities of the three sludge aggregates as well as sand at various particle sizes were determined. The results are reported in Table XIII.

The pellets used to make the three types of aggregates were produced by mixing dry powdered sludge with wet sludge in a planetary mixer at low speed.

Table XIII. Comparison of Apparent Bulking Density of Sludge Aggregates and Sand

Particle size range (U. S. sieve number)	Apparent bulking density, lb./cu. ft. Sand, 212°F.	Bloated sludge, 2300°F.	Calcined sludge, 2300°F.	Dried sludge, 212°F.
Above 3/8"	90.5	15.2	...	...
3/8" to 4	92.9	19.3	43.7	36.1
4 to 8	93.1	32.0	50.0	36.3
8 to 16	94.7	38.3	48.3	38.4
16 to 30	95.0	41.4	49.9	37.6
30 to 50	95.7	41.6	47.0	37.8
50 to 100	94.0	44.9	52.0	37.4
Below 100	101.0	86.5[a]	54.0	38.3

[a] The finer fractions were produced by crushing bloated sludge. The fraction finer than no. 100 consisted of fragments, thus causing the high apparent bulking density.

Pellet formation started at a moisture content of about 55%. By adding more dry sludge to reduce moisture content, smaller pellets were formed. Classification by means of sieves yielded fractions of different sizes. Bloated aggregates, finer than a U. S. sieve no. 30, were produced by crushing larger aggregates.

An aggregate mix was designed to obtain the particle size distribution within the limits set up by the American Society for Testing Materials, Specification C33, and by the Bureau of Reclamation (*24*). Table XIV illustrates the aggregate mix and fineness modulus used to make test concrete cylinders from bloated sludge, calcined sludge, dried sludge as well as sand.

Test concrete cylinders 2 in. in diameter and 4 in. high were produced from fine aggregates. The water-soaked aggregates were thoroughly mixed with commercial cement and additional water. The concrete was placed into molds as specified by the ASTM, Tentative Method C 192–47 T, Making and Curing Concrete. The cylinders were capped with cement, removed from the molds after 24 hr. and cured at 100% R.H. for 27 additional days. Evaluation for compressive strength was carried out by means of hydraulic press following the ASTM procedure. The density was determined after drying at 100°C.

Table XIV. Particle Size Distribution and Fineness Modulus Used to Product Test Concrete Cylinders

U. S. sieve number	Volume aggregate in each sieve range, (cc.)	Fineness modulus (weight retained %, cumulative) Sand	Bloated sludge	Calcined sludge	Dried sludge
Above 4	20	2.0	0.9	1.8	2.0
4 to 8	110	14.6	10.9	14.9	14.4
8 to 16	170	34.4	29.3	34.3	34.8
16 to 30	170	54.2	49.0	54.4	54.7
30 to 50	205	78.2	73.0	77.2	78.7
50 to 100	150	95.5	92.0	95.7	96.2
Below 100	25	...	...	...	...
Total	850	100.0	100.0	100.0	100.0
Fineness modulus	(24)	2.79	2.55	2.78	2.81

For the production of concrete from bloated and dried sludge, three different ratios of aggregate to cement were used: 4.7, 3.7, and 2.7 cc. of aggregate per gram of cement. Only one ratio, 4.7, was used with calcined sludge aggregates and the sand standard. The aggregate-cement ratio was expressed in the form of a volume to weight relationship on account of great

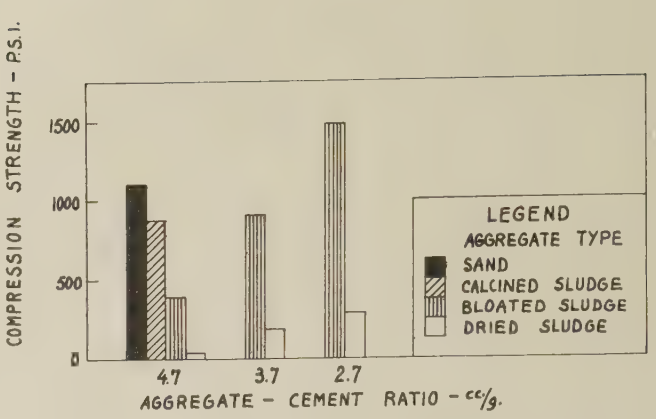

Fig. 4. Comparison of compressive strength of concrete cylinders made using sand and sludge aggregates

difference in density between sand and sludge aggregates. By using this method, a fair comparison of physical characteristics of the concrete cylinders could be made on the basis of volume of raw materials used to the volume of concrete produced.

Figures 4 and 5 show the results of strength and density determinations for concrete made from the various aggregates and at the various aggregate-cement ratios. All three types of sludge aggregates yielded concrete of lower density than sand, the dried sludge pellets producing the lowest density. At an aggregate-cement ratio of 2.7, bloated sludge produced concrete cylinders with a comparative strength of 1488 p.s.i., whereas dried sludge pellets yielded cylinders of 280 p.s.i. compressive strength.

In an attempt to make stronger concrete and to utilize the high yield of particles below 100 mesh produced when bloated aggregates were crushed, a new aggregate mixture was formulated, within the upper limit of the specifications of fineness modulus and ASTM Specification C 33-46 for fine aggregates. Sand was used as basis for the calculations. Table XV presents the proportions of aggregate in each particle range and fineness modulus for the newly designed aggregate mixture designated "Mix Two."

Concrete cylinders, made from bloated sludge and the newly designed aggregate mix were stronger than those previously reported in Fig. 4. The greatest strength increase was observed at an aggregate-cement ratio of 4.7. Compressive strength increased 83.5%, from 385 to 706 p.s.i. "Mix Two" caused some increase in density; however, this increase was less than 7% in all cases and may be considered insignificant in view of the strength increase. Figure 6 compares the compressive strength of concrete made from the two aggregate mixes whereas Fig. 7 compares the densities.

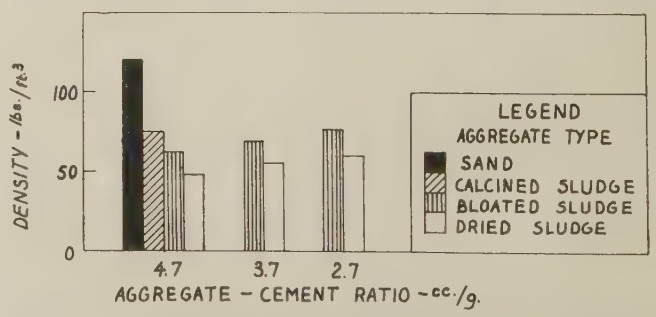

Fig. 5. Comparison of density of concrete cylinder made using standard sludge aggregates

Table XV. Comparison of the Two Aggregate Mixes

U. S. sieve number	Volume of particles in each sieve range	
	Mix 1,[a] cc.	Mix 2, cc.
Above 4	20	41
4 to 8	110	128
8 to 16	170	136
16 to 30	170	246
30 to 50	205	145
50 to 100	150	85
Below 100	25	69
Fineness modulus		
Sand	2.79	2.97
Bloated sludge	2.55	2.60

[a] Mix 1 as presented in Table XIV.

The light color of bloated sludge suggested its use as aggregate in white specialty concrete products. Therefore, tests were made using light-colored cement. The resulting concrete was white and possessed essentially the same strength and density as concrete made from normal concrete. Table XVI compares the results obtained for concrete made from both normal and white cement.

ELECTROPHORETIC EXPERIMENTS

Clay, having dimensions in the colloidal range, has a negative charge in aqueous dispersion. Therefore, the particles migrate in an electric field to the anode. This electrochemical behavior is known as cataphoresis or electrophoresis. Details are discussed in Lewis, Squires, and Broughton's textbook (*25*). Experimental procedure for electrophoresis experiments may be found in Hauser and Lynn's "Experiments in Colloid Chemistry" (*26*).

Table XVI. Comparison of Concrete Cylinders Made from Bloated Sludge Using Normal and White Cement

Aggregate-cement ratio, cc./g.	Compressive strength, p.s.i.		Density, lb./cu. ft.	
	Normal cement	White cement	Normal cement	White cement
4.7	706	605	69.3	69.3
3.7	1035	1011	73.0	74.0
2.7	1925	1910	79.0	80.1

Trial tests were made to determine if clay could be separated from deinking sludge by electrophoresis. A rectification circuit to convert a.c. to d.c., a 25,000-ohm resistor, permitting regulation from 100 to 400 v., platinum electrodes, and two extra coarse fritted glass extraction thimbles were used.

At low voltages there was no apparent separation of clay; however, at a higher voltage output of the rectifier, small amounts of a light-yellowish solid were observed to collect at the anode after a period of about an hour. Substantial quantities of gas were evolved at the electrodes. The experiments were discontinued since the cost of electrical power needed seemed to be in excess of the value of the produce recovered.

FLOTATION EXPERIMENTS

Froth flotation was investigated as a possible method to recover clay from sludge. Flotation is a well-known unit operation for separation and concentration of mineral ores (*27, 28*).

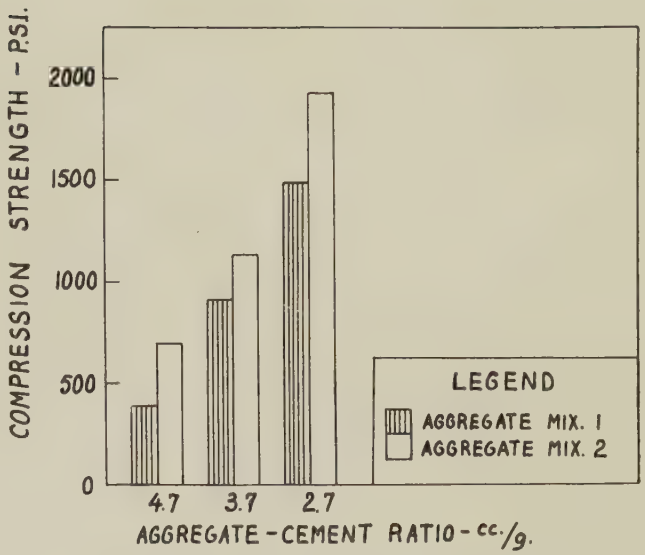

Fig. 6. Comparison of compressive strength of concrete cylinders made from 2 aggregate mixtures

Attempts were made to obtain two fractions, namely, a dark foam containing the carbon black as well as part of the clay and a light-colored fraction of clay remaining in the cell as "tailings."

The flotation cell consisted of a motor driven rotor and a standpipe connected to a stator. Air entering the flotation cell was controlled by a petcock attached to the standpipe. The air passed through an annular space between the rotor and the stator into the sludge.

Kerosene as well as pine oil were used as collectors for carbon black. These liquids and a frother, used to produce a stable foam, were added to the sludge. After a conditioning period of 10 min., the air petcock was opened and the cell operated for an additional 10 min. Due to the high viscosity of sludge, the maximum solids content used was approximately 5%. Solids concentrations of 3% were preferred. Determinations of ash content and photovolt brightness was made using the solids of the starting material, of the foam, and of the tailings. Brightness pads were prepared by allowing the samples to dry in Petri dishes at 177°F.

Flotation experiments performed on deinking sludge showed that separation actually took place. Starting

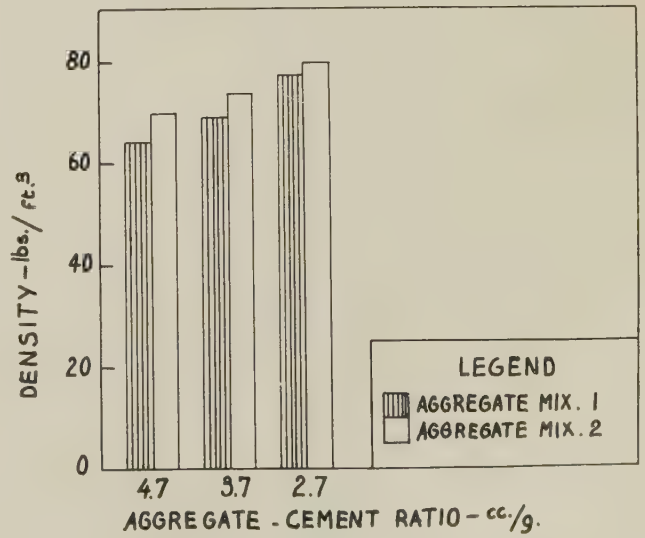

Fig. 7. Comparison of density of concrete cylinders made from 2 aggregate mixtures

with sludge having a photovolt brightness of 44.5%, an ash content of 55.3%, and a pH of 7.8, flotation produced solids in the foam of 32.5 to 35.5% brightness

Table XVII. Comparison of Pine Oil and Kerosene as Collectors for Carbon Black

Type of collector	Foam		Tailings	
	Brightness, %	Ash, %	Brightness, %	Ash, %
Kerosene	32.5	67.9	53.0	49.3
Kerosene-pine oil in equal parts	32.5	63.8	52.5	49.0
Pine oil	39.0	56.2	46.5	54.1

Quantities used: 60.0 g. of sludge solids, 1940 g. of water, 7.4 g. of collector and 0.2 g. of frother S-2065 (American Cyanamid Co.).

and 66.2 to 67.9% ash. The solids of the tailings had a brightness of 53.0 to 54.0% and an ash content of 45.6 to 49.3%. The tailings amounted to about 62.0% of the material introduced into the cell. High ash content of the foam indicated that some of the clay was floated off along with the carbon black. The low ash content of the tailings were caused by considerable quantities of fiber.

Straight pine oil and kerosene oil as well as an equal mixture of both were tried as collectors for carbon black.

Straight kerosene yielded best results. Table XVII shows the outcome of the experiments. Sulfuric acid was added to deinking sludge to determine if better separation could be obtained at lower pH levels. This caused a reduction of brightness and an increase in ash content of the tailings accompanied with a decrease in ash content and increase in brightness of the foam. Figure 8 expressed the experimental results.

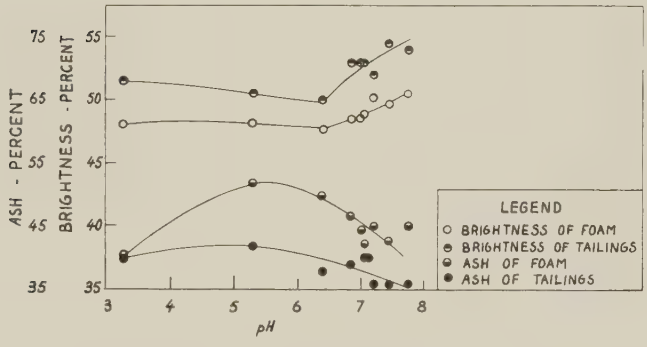

Fig. 8. Effect of pH on the separation of deinking sludge by froth flotation

Two samples of tailings were bleached at 73°F., for 24 hr. using an excess, namely, 10% chlorine in the form of sodium hypochlorite. Brightness increased from 54.0 to 64.5% for one sample and from 55.0 to 67.5% for the other. The color of the bleached product was slightly gray indicating that not all the carbon had been removed.

Further experiments by means of flotation seem to be advisable.

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Characteristics and Performance of Rayon Tire Cords

MATTHEW W. WILSON

Rayon tire cord characteristics observable in the laboratory are discussed and related to tire performance. Effects of improving tensile strength are considered and the methods of measuring fatigue resistance are reviewed. Particular attention is given to the characteristics that are related to the interaction of rayon tire cords with water. Shrinkage, penetration by adhesive, effect of wetting on tensile strength, elongation, and resiliency are covered. Factors involved in improving cord tensile strength and resiliency are examined. Considerable attention is paid to all factors affecting adhesion, and a mechanism of resorcinol-formaldehyde-latex adhesion is presented.

CHARACTERIZING RAYON FOR TIRE CORD

Tensile Strength and Fatigue Resistance

THE first characteristic of a tire cord that one recognizes is tensile strength. And this is the primary consideration in the case of a tire cord made from regenerated cellulose fibers. There are other fibers where this would not be so. In the case of glass fibers, for example, brittleness would be the primary consideration. In the case of certain other fibers, it might be thermoplasticity. But if one reinforces a tire with almost any regenerated cellulose fiber, as long as enough material is provided to give a high factor of safety to the tire tensile strength, this tire can be expected to perform quite well. Of course, it is known that certain regenerated cellulose fibers are stronger than others and some are better in other characteristics. For practical purposes certain ones have an advantage.

The tensile strength of rayon tire cords has been improved very markedly since their introduction. Table I shows past and present tensile strengths. The 1100/2 cord was the first rayon cord in really wide use and was the one used throughout World War II. The 1650/2 cord then took over, but recently the 1100/2 has returned in super-super or Tyrex form and is now very commonly used, particularly in passenger tires.

Increasing the tensile strength has, of course, allowed the tire industry to reduce the weight of cord and recently, in returning to the 1100/2 cord and using it in super-super form, has allowed the tire industry to also reduce the weight of rubber. An example of weight reduction is found in the change from a moderately-super 1650/2 cord to the super-super or 1100/2 Tyrex cord. Such a change allows one to reduce the weight of rayon by 10% or better.

Cool running is, as everyone now probably knows, one of the important factors in tire performance. Cool running protects the tire cord itself, but even more important in many cases, it protects the rubber. Truck tires can blow-out as a result of the tire cord becoming overheated, fatigued, and ruptured. Passenger tires are very much less likely to fail from such a cause. The passenger tire failure connected with heat is a tread separation. This may be a separation from the cords themselves but it is more likely to be the separation which takes place entirely within the rubber compound. The rubber compound simply weakens or reverts at the high temperature conditions and comes apart. But regardless of the mechanism of failure, cooler running is the preventative, and the surest way of accomplishing this is to thin the tire. This can be done in some cases through the use of larger cords and in other cases by the use of smaller cords. In either case, the higher the tensile strength of the material, the better. Other things being equal, the strongest ply of fabric is made from the largest cord. So, in some cases one can reduce carcass thickness and obtain cooler running by using a larger cord and fewer plies of fabric. This applies to heavy duty tires, but is also considered for passenger tires in the two-ply construction. On the other hand, the smaller cord, such as the 1100/2, can be used for cooler running in heavy duty and passenger tires when it has sufficient strength so that it can replace a 1650/2 cord ply for ply.

Thus, depending upon the earlier standard, the increase in strength of rayon cords enables one to

Table I. Tensile Strength
Ovendry Measurements

Construction	*Past, lb.*	*Present super-super, lb.*
1100/2	17–19	25–27
1650/2	25–28	37–39

Table II. Roto-Flex Results

Rayon		*Fatigue life, hr.*
	4-lb. Load	
28 lb. Specimen	1650/2 Construction	1.6
Moderately super	1650/2 Construction	2.4
Super	1650/2 Construction	3.6
Super-super	1650/2 Construction	5.0
	3-lb Load	
Experimental cellulosic	400/4/2 Construction 11.5 × 10.5 Twist 33.4 lb. Tensile strength	1.5
Viscose rayon	1650/2 Construction 11.5 × 10.3 Twist 27 lb. Tensile strength	4.5

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produce thinner and cooler running heavy duty tires by staying with the present 1650/2 cord, going to a larger size cord, or adopting the 1100/2 construction. It enables one to build a cooler running passenger tire by going to the smaller 1100/2 size.

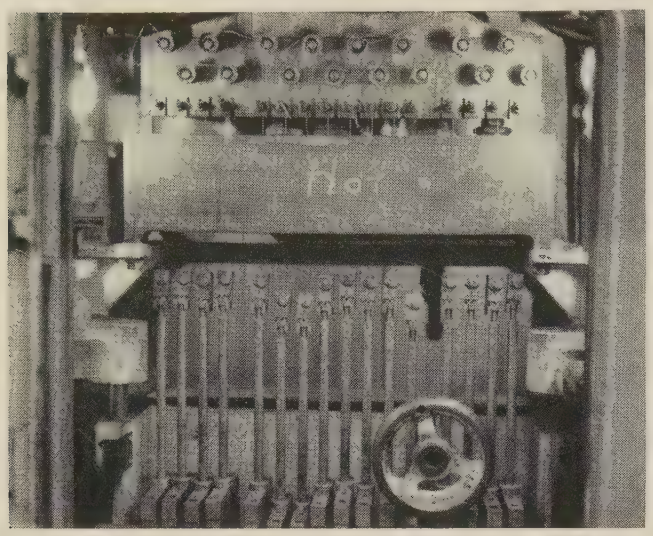

Fig. 1. B. F. Goodrich cord vibrator

This paper does not go into the "heat-resistance" characteristic of rayon. This is a considerable subject in itself. It shall be passed by with the statement that rayon is the classic example for heat-resistance in tire cord and that cellulose can hold its own very well when subjected to heat.

Although almost any cellulosic tire cord has sufficient fatigue resistance to make a tire for a given utility, the fatigue resistance of the material determines how much cord must be used and what cord construction is used. The new higher strength rayons could not be used in tires with lower cord weight if their fatigue resistance had not been improved along with their tensile strength. A more brittle or more readily fatigued rayon can be used for a given tire, but it must be twisted to a higher degree to make up for its more readily fatigable nature. When this is done, the tensile strength, of course, suffers. Better fatigue resistance is just as desirable as higher tensile strength. The ideal improvement in cellulosic fibers is one in which the fatigue resistance keeps pace with the tensile strength.

Fatigue resistance is measured in several different ways and the ideal characterization of a cellulosic fiber or any other fiber with regard to fatigue resistance makes use of several different tests. An example of what might be considered an ideal arrangement for characterizing fatigue would comprise a tension fatigue type of test on cord alone, a flex fatigue type of test on cord alone, and a combination of tension-flex test in which the cord is tested in rubber.

Figures 1–3 illustrate these three types of tests and are examples with which the present author is most familiar. Figure 1 shows the B. F. Goodrich Cord Vibrator (*1*, *2*). This is the tension fatigue type of test. In this test, the cord may be considered under a dead load and at the same time being vibrated. The test conditions are related to what one will have in a heavy duty tire operating at high load and high temperature. It is the type of test which first demonstrated the high temperature possibilities of rayon and correlated with heavy duty tire performance.

Figure 2 shows a Roto-Flex test (*3*, *4*, *5*). In this the cord is flexed as though it were worked over a tiny pulley and this evaluates the brittleness or flexibility of the cord. It differentiates very well the brittle from the more flexible cellulosic fibers. This test correlates well with the fatigue resistance of a passenger tire; this type of fatigue being one associated with severe flexing and conditions of low inflation pressure and high overload. Since this type of fatigue does not involve high temperature in the manner of the heavy-duty tire, this test is effective at room temperature.

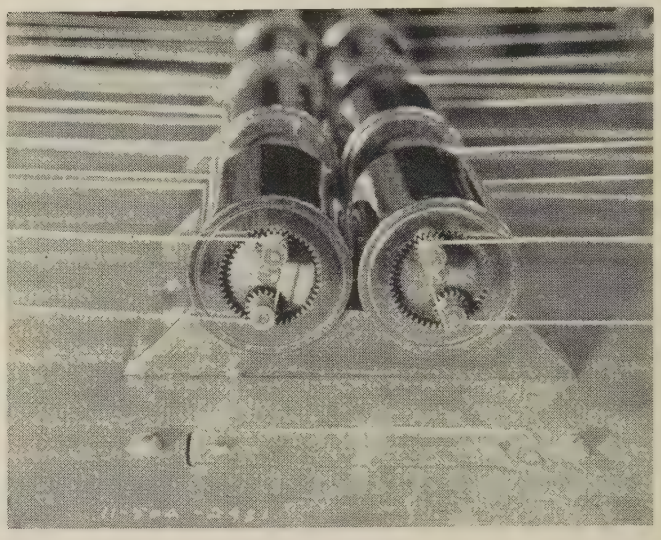

Fig. 2. B. F. Goodrich Roto-Flex test

Figure 3 shows the third type of fatigue test, the one in which the cord is embedded in rubber and given both a tension and a flexing action. This test is known as the Disc Test (*6*, *7*) and is one which applies a

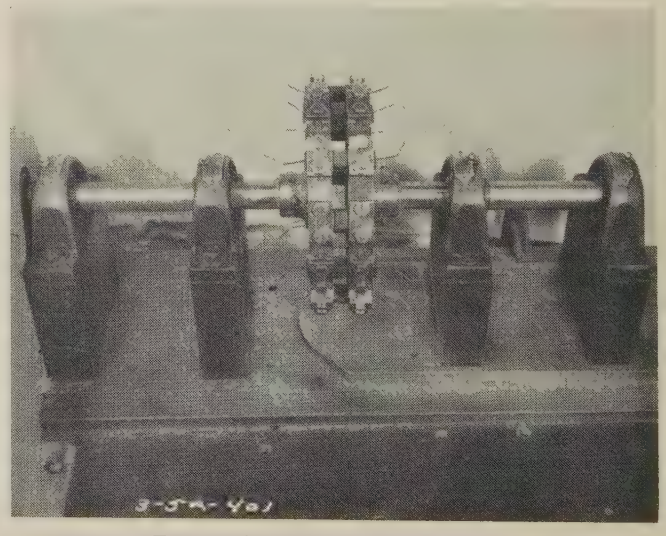

Fig. 3. B. F. Goodrich disk test

direct and longitudinal compression (along the axis) to the cord, such as it may obtain as a result of being encased in the rubber of the tire. This test correlates with the cord treatments that are used in processing the cord into the rubber. It can be used to evaluate the effect of dipping treatments which can tend to stiffen the cord and this test can also be used to investigate the part played by cord adhesion in resisting fatigue in the tire.

Table II shows the nature of fatigue improvement in rayon in going from the old standard material through the super and super-super varieties. It also gives a comparison of one of the most brittle rayons with the regular tire cord material.

Characteristics Connected with Dipping

A tire cord must have adhesion to rubber and it cannot come by this naturally. It requires treatment with an adhesive which, in practically every case, is an aqueous dispersion known as RFL, resorcinol-formaldehyde-latex. Talking about aqueous dipping, one gets into the question of how rayon filaments and cords are affected by water. This leads more specifically to the subjects of:

a. How water can disorganize rayon cords and the filament itself.

b. How the tensile strength, elongation, and resiliency can be adversely affected by water. Conversely,

c. How water can soften rayon so that, with suitable tension, the tensile strength of the cord can be improved, the elongation reduced, and the resiliency improved.

d. How the dip can penetrate and whether it penetrates too much; furthermore, how the RFL in the dried cord can affect the stress distribution in the cord.

e. How the adhesive can anchor itself or is repelled from the surface of the filaments.

Water can be a blessing or a curse to the rayon cord. One might say that the rayon tire cord is not a stable entity but that its state depends upon a number of conditions present at the time that the cord is in contact with water, either in the liquid or vapor phase.

The tire cord user assumes that the rayon filament itself can be affected by water, because he knows that when rayon cords are thoroughly wetted-out under relaxed conditions some rayons are more adversely affected than others. One expects a rayon cord to shrink under a wetting treatment and be damaged simply because of a disorganization of cord structure, but some rayons are found to lose tensile strength and modulus to a greater degree than others. One, therefore, concludes that there has been disorganization beyond that of the cord alone and that the filaments themselves have suffered. Experiments, to demonstrate this point, fall more in the realm of the rayon producer.

In spite of the acknowledged sensitivity of rayons to water, the relative resistance to the unstabilizing action of water is a subject generally ignored because it is always understood that the rayon cord should go into the tire in a completely dry state. However, the stability of a particular rayon (the filaments themselves) against water may have the opportunity to play some part in the subsequent performance of the tire, because the moisture content of the tire does not remain at zero. Furthermore, fabric sometimes stands around before it is built into the tire and has the opportunity to pick up moisture.

As already mentioned, the cord structure is unstable. This is so because the yarn is unstable. In order to make a suitable tire cord yarn, the yarn after spinning is wetted and tensioned to reduce its elongation. This is the well known slashing treatment. It is, of course, recognized that if the yarn or the cord made

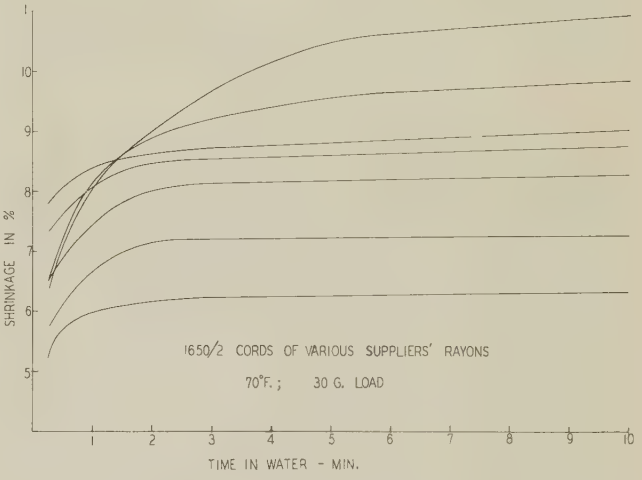

Fig. 4. Rate of shrinkage of different cords

from this yarn is wetted in a relaxed state and allowed to dry in this condition, it will return to its original unstretched state.

The word "unstable" may be a bad one to use in this day of severe competition. However, we can ease the situation by saying that all tire cords an unstable. Some are unstable to one set of circumstances and others to another set of circumstances. Even wire tire cord is unstable if we let it stand in a rusting atmosphere. On the other hand, the term "unstable" is a good one to use if it helps us to understand the treatments which are necessary for the proper use of rayon tire cord.

Aside from the cellulose, a factor affecting the action of water is the finish applied to the rayon. Some finishes are more hydrophylic than others and so the rate at which water affects the rayon cord is dependent upon this finish factor.

A good place to start in studying characteristics brought up by the subject of dipping may be this last named factor, "finish." Figure 4 shows the rate of shrinkage of different cords. In this test, the cord is held at a given tension, immersed in water, and the amount of shrinkage measured. It is seen that the cords have different shrinkage rates as well as different amounts. Some attain their maximum shrinkage early and others only after a considerable time. These effects are readily attributable to the finish on the filaments. A hydrophylic coating on the surface of

the filament will allow rapid wetting and this should allow rapid cord shrinkage and quick attainment of maximum shrinkage. A hydrophobic finish will reduce speed of wetting and cause a slow attainment of the maximum shrinkage. Some tentative conclusions may be drawn at this point. For one thing, the cord with the low shrinkage rate is going to be one that will not require as much rigid control during plant processing. Since it does not wet so quickly, it should not tend to lose tensile strength so readily or tend to gain elongation so readily. It will tend less to "rope" in a weftless system of processing, but it may tend to have a lower adhesion because not being so highly wettable, it will not be penetrated so readily by the aqueous RFL. It will have a smaller tendency to pick up as large a quantity of the dip. Furthermore, its lack of wettability indicates that the adhesive will not have as intimate a contact with the cellulose and, for this reason, will give lower adhesion.

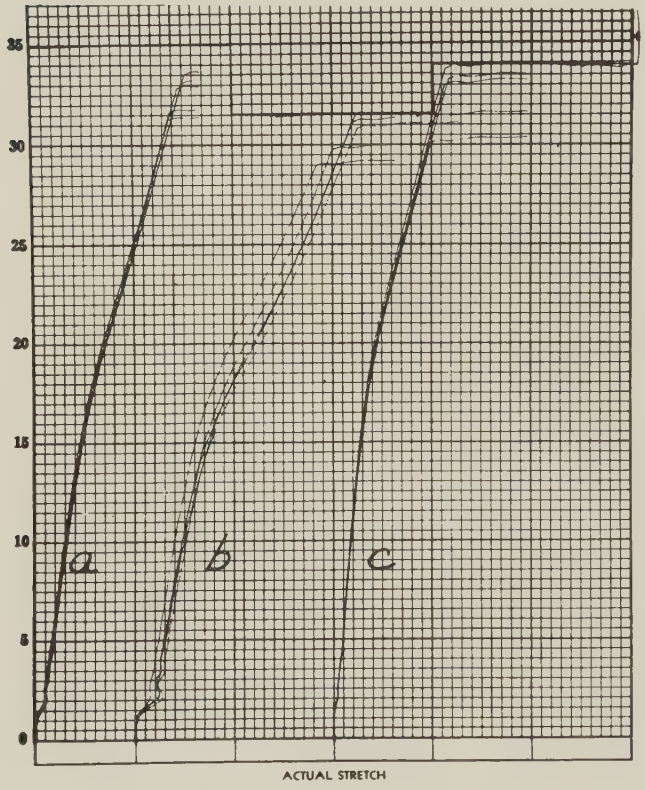

Fig. 5. Stress-strain curves

(a) Cord from the twister; (b) same cord water relaxed and dried under light tension; (c) same cord with high dipping and drying tension.

It has been stated that a tire cord structure is unstable to water when in the relaxed state because of the history of the yarns. These yarns were wet-tensioned and dried under tension in their preparation. They will now produce an irreversible shrinkage when the cord is wetted and dried in the relaxed state or at a low tension approaching the relaxed state.

Figure 5b shows a stress-strain curve for a cord which has been wetted and allowed to dry in a relaxed state. Particularly significant is its high stretchiness near the origin. Common experience with textiles tells us that under stress this stretchy cord will tend to return to its state of low stretch. Without the help of water or moisture, it cannot return that effectively, but, nevertheless, it is going to *tend* to return. Such a thing, we say, has the property of showing a *permanent set* from its state of higher stretch.

It is found that a drying tension of 1 to 2 lb. for a 1650/2 cord and, correspondingly, $^2/_3$ to $^4/_3$ lb. for an 1100/2 cord, is necessary after dipping to prevent ending up with a cord having slackness at the stress-strain origin. It may be found desirable to use a drying tension higher than the minimum, which prevents shrinkage, to obtain a still lower stretch and other desired characteristics. This will be discussed later. The minimum tension to prevent shrinkage can be determined by measuring the shrinkage tension as well as by running a series of drying tests at different tensions.

Having now recognized that there is a minimum drying tension, it is next desirable to know how much dipping tension to use. On a simple laboratory dipping machine, the drying tension will change with the dipping tension. This is also true of much plant equipment, because on a practical machine it may be difficult to isolate the dipping from the drying tension. At any rate, in our study of dip tensions, as long as the drying tension is sufficient to prevent slackness at the stress-strain origin, the effect of change in dip tension can be studied.

Table III shows the effect on tensile strength as a result of dipping in RFL for three different rayons. The first of these rayons, which has a low shrinkage characteristic, shows loss in tensile strength at low dip tension. The dip was apparently able to penetrate and reduce the tensile strength in this case, perhaps because the water did not swell the fibers sufficiently to prevent penetration. The second rayon has a higher shrinkage tendency and does not show quite as much loss in tensile strength. Perhaps this can be interpreted as an effect of the filaments swelling and resisting RFL penetration. In the third case, there is very little tensile strength loss on dipping. This is difficult to explain. It also does not necessarily mean that it is the best rayon. One must feel that a hydrophobic factor is involved here which, generally, means a possible difficulty with adhesion. One expects a rayon to show a tendency to a certain amount of loss, and of course, a minimum loss for the required amount of adhesion is wanted.

The loss in tensile strength may not look too significant and, by itself, may not be. In the case of the lowest tensile strength values, the worst effect might be from too much RFL penetration, which might lower the fatigue resistance. However, it may be added that in practice a low dipping tension may also means a low drying tension as well and this combination could cause serious difficulty.

The foregoing tests characterize the rayon cords under conditions which are close to those which the cord will experience in practice. In order to further analyze the effect of wetting on the tensile strength and elongation and to separate effects of water and of

RFL, a similar set of dipping trials was run using both water and RFL and extending the dip tension used.

For this series, a comparison was made between a moderately-super and super-super rayon. Since a moderately-super rayon was not available in the 1100/2 construction, 1650/2 cords were used.

Table IV shows the data obtained. It can be seen first of all, and this follows from the previous data, that RFL can lower the maximum obtainable tensile strength of the cord. This is undoubtedly a stress distribution effect and not actually cellulose damage. Next, it can be seen that in a water treatment there is a considerable improvement in the tensile strength of the cord as the dip tension is increased. In this particular case, the improvement of one cord is much greater than for the other.

Our interpretation of all these phenomena as related to the subject of the tensile strength of the cord should probably be the following. The water component of the dip can disorganize the cord during low tension dipping, but if water were the only material involved, the normal drying tension of about 1 lb. per cord, or a little more, would reorganize the cord so that there would be no loss in tensile strength. In such a short treatment, of course, there should be little time for any damage within the filament. However, consider the RFL component. At low dipping tensions, water disorganizes the cord and RFL can penetrate. In the dry cord, this RFL can be an interfering material when the fibers are loaded. It can alter what would be the normal stress distribution and, for this reason, lower the tensile strength of the cord.

To return to the effect of the water, it can be seen that this could be an aid in raising cord tensile strength and this effect has been known as "equalizing" (*8*). The cord as normally received from the twister does not get the best possible stress distribution when loaded. However, wetting and tensioning adjusts the cord to a more uniform structure and one which gives better stress distribution. To obtain the actual quantitative improvement from "equalizing," one should subtract the effect of twist reduction, since this, of course, also contributes to the gain in tensile strength.

Table III. Dipping Tests
1100/2 Cords: 12% RFL Dip

Dip tension, g.	*Resulting tension out of oven, lb.*	*Rayon No. 1* Tensile strength, lb	*Rayon No. 1* Elong. % @ 10 lb.	*Rayon No. 2* Tensile strength, lb.	*Rayon No. 2* Elong. % @ 10 lb.	*Rayon No. 3* Tensile strength, lb.	*Rayon No. 3* Elong. % @ 10 lb.
Control	...	25.8	3.9	25.9	2.9	25.0	3.0
50	1	24.1	3.2	*24.9*	2.5	25.0	2.9
100	1 1/8	*23.6*	3.1	25.3	2.6	25.0	2.5
150	1 1/4	24.3	3.0	25.5	2.4	25.2	2.5
200	1 3/8	24.5	3.1	25.0	2.4	25.1	2.4
300	1 5/8	25.4	3.0	25.4	2.2	25.0	2.2
400	1 7/8	25.9	3.0	25.0	2.4	25.1	2.1
Shrinkage 30 g.; 1/4 min.		6.2%		8.5%		7.0%	
Shrinkage 30 g.; 10 min.		7.5%		9.7%		8.2%	

Our interpretation of all these phenomena as related to the subject of the tensile strength of the cord should probably be the following. The water component of the dip can disorganize the cord during low tension dipping, but if water were the only material involved, the normal drying tension of about 1 lb. per cord, or a little more, would reorganize the cord so that there would be no loss in tensile strength. In such a short treatment, of course, there should be little time for any damage within the filament. However, consider the RFL component. At low dipping tensions, water disorganizes the cord and RFL can penetrate. In the dry cord, this RFL can be an interfering material when the fibers are loaded. It can alter what would be the normal stress distribution and, for this reason, lower the tensile strength of the cord.

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Resiliency

We now turn to another characteristic which has been mentioned under those affected by the instability of rayon tire cord to water. This characteristic is resiliency.

Resiliency is the ability to recover from a deformation and this factor undoubtedly plays an important part in the performance of a tire. Rayon, like any other material, will tend to have a certain amount of permanent set when subjected to a load. This permanent set can affect the performance of a tire. If dipping the cord in a water dispersion reduces the tensile strength and circumstances are such that the elongation is raised, it can be expected also that the resiliency is decreased. Conversely, it may be expected that if the tensile strength and elongation are unaffected by dipping, the resiliency remains the same. However, it is possible to improve upon the resiliency of the untreated cord by taking advantage of the plasticizing action of the water during dipping.

This is done by raising the dipping and drying tensions to a certain level. This tightens down or draws the

Table IV. Dipping Tests
1650/2 Cords: Water and 12% RFL Dips

Dip tension, g.	*Tension out of oven, lb.*	*Moderately-super rayon* Water Tensile strength, lb.	Water Elong. % @ 30 lb.	RFL Tensile strength, lb.	RFL Elong. % @ 30 lb.	*Super-super rayon* Water Tensile strength, lb.	Water Elong. % @30 lb.	RFL Tensile strength, lb.	RFL Elong. % @ 30 lb.
Control	...	32.7	11.6	32.7	11.6	36.0	9.1	36.0	9.1
50	7/8	...	...	...	...	35.7	9.5	35.3	8.7
100	1	32.8	12.0	31.1	12.0	38.2	9.2	36.7	8.7
200	1 1/4	32.8	11.5	31.5	11.4	38.6	8.6	35.4	9.2
400	2	32.8	10.4	32.4	10.9	37.9	8.0	35.7	8.1
600	2 1/2	33.5	10.5	31.4	9.6	39.5	7.7	35.1	8.2
800	3	33.5	9.9	32.0	9.4	...	...	...	...

cord. It would be expected that this tightening or drawing action on the cord in the wet state will bring together polar groups on adjacent molecules to form physico-chemical intermolecular bonds (hydrogen bonds) and that bonds thus formed will not be potentially available for producing permanent set under some subsequent loading. The tightening down or drawing action on the cord is also important economically. It is possible to obtain a gain in cord length amounting to several per cent. Figure 5c shows an improved stress-strain curve over the original by a wet tensioning treatment.

While studying the effect of wetting, tensioning, and drying on resiliency, it is interesting to look at two different types of rayons. In fact, the way to make a comparison of the resiliencies of two different rayons would be on dipped samples. The reason is that dipping and drying under given tensions brings the

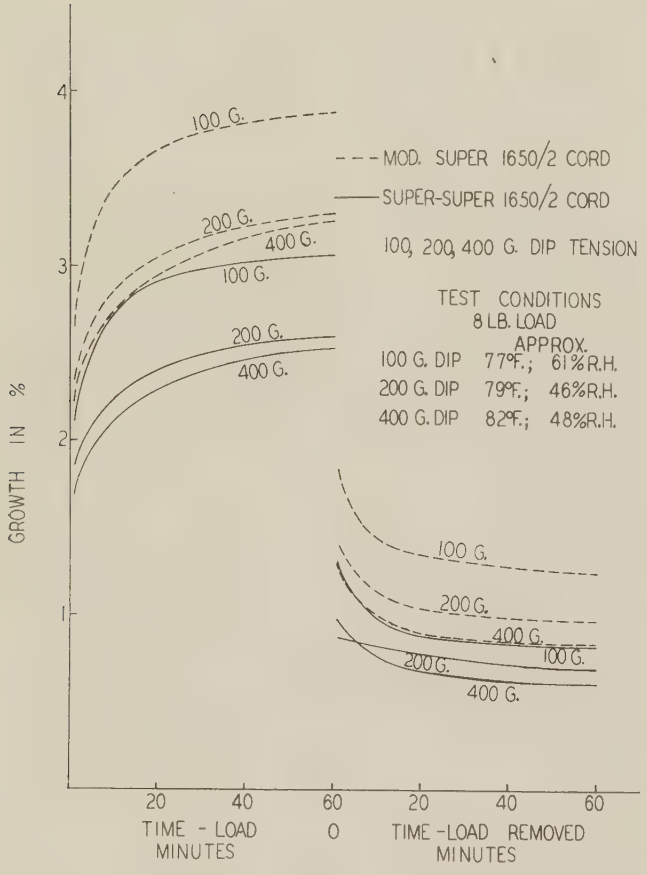

Fig. 6. Growth and recovery of water dipped rayon

cords of different rayons to a more common state. One cord being compared might have been made from a rayon that was slashed at a higher tension than the other. The dipping and drying under a given set of conditions would tend to equalize these cords.

There are two ways of treating rayon cords for these tests and these methods cover procedures which might be considered for factory processing. In the first case, the cord is dipped at different tensions, passed through the drying oven, and wound on a spool. The drying oven will probably have enough friction in the pulleys over which the cord travels to raise the tension to that which the cord might have in factory processing.

For example, a tire cord dipped in RFL at 200 to 300 g. and carried out of the drying oven at 450 to 900 g. will be very close to many plant processes.

Another type of treatment consists of dipping or soaking the rayon at a very low tension, snubbing it on a capstan, then on a second capstan, with a drying oven between capstans. By using a differential speed on the capstans, a controlled tension is produced and the cord may be studied by using a variety of these. Such a treatment might also be used in production but it could not be done as simply as this. If the treatment is simply carried out using RFL of normal concentration for adhesion, the cord will tend to be very stiff and would not be expected to last long in a fatiguing action. To adapt such a system to production, a combination of wetting with water and dipping in RFL would be desired because this method would tend to keep the RFL on the outside of the cord where it belongs.

After having treated the cords, the simplest procedure to use in order to get an idea of cord resiliency is a dead-load growth, or creep test. In this test, a load is applied gently to a cord and the elongation followed with time. By this test, good comparisons can be made between different rayons because different rayons can be tested side-by-side, at exactly the same time, and under identical conditions of temperature and humidity. For the tests reported here, a room temperature condition was used for convenience.

In this study, a rayon cord of 32 lb. strength, which we shall refer to as moderately-super, is compared with a cord of 37 lb., which we shall refer to as super-super. Both cords are of 1650/2 construction. Samples were prepared at 100, 200, and at 400 g. dip-tank tensions. The drying tensions were not controlled but are constant for a given dip tension. The treatment was made with both water and RFL. The following results are representative of a number of tests.

Figure 6 shows the growth tests on the water treated samples and Fig. 7 shows the test for the RFL treated cords. In both cases, it can be seen that the super-super cord has a lower growth and recovers closer to its original length than does the moderately-super cord. The lower growth can be interpreted as meaning better resiliency as well as can be the better recovery to original length. This interpretation follows from the idea that this growth is partially plastic flow, which, of course, is opposite to resiliency.

Figure 8 shows a comparison of a super-super cord dipped at 100 g. with the moderately-super dipped at 400 g. It can be seen that the 100 g. dipped cord compares favorably with the 400 g. dipped cord, further demonstrating the better resiliency of the super-super cord.

Figure 9 shows growth results on cords which have been treated by the second method, namely dipping at a low, controlled tension, which was less than 50 g., but dried at higher and controlled tension. Again, it is seen that the super-super cord shows greater resiliency. This figure also shows that a lower tension in the case of the super-super cord is almost as effective

as a higher tension in the case of the moderately-super cord.

The difference in resiliency between these two rayons, of course, is not tremendous and it cannot be claimed that this difference would be an important factor in tire performance. Nevertheless, it is indicative of the type of improvement that is made in rayon and, furthermore, this difference in resiliency probably is not simply a function of strength. Each higher strength rayon may not necessarily show this sort of improvement in resiliency.

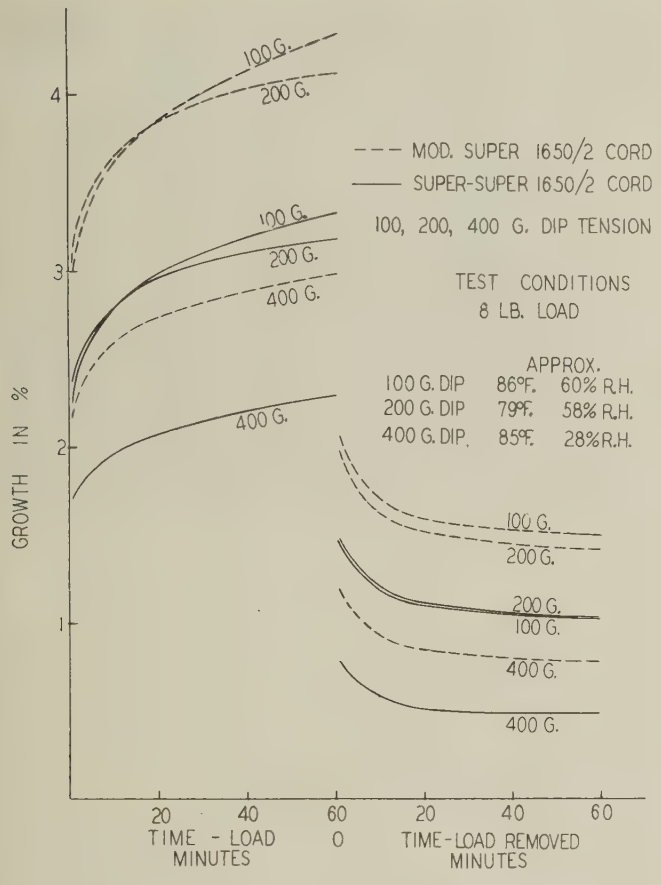

Fig. 7. Growth and recovery of RFL dipped rayon

An obvious conclusion can also be added and this is that wet-tensioning produces better resiliency.

Adhesion

Adhesion is tested first of all by simply immersing a piece of cord in a quantity of RFL, drying it so as to have no change in length and twist, and then curing it in rubber and measuring the force to pull the cord out of the rubber or force the rubber off the cord. By such a method, many suppliers' rayons will show reasonably good adhesion and, although there may be some differentiation, the members of a group of rayons may show very little difference with respect to adhesion. However, this is not the type of adhesion treatment which a cord receives in being prepared for a tire. In practice, it is passed through the RFL very quickly, and excess removed just as quickly. It is also under a certain amount of tension as it goes through the dip tank and this requirement has already been discussed. The rayon cord must, therefore, have a potential of quickly forming a combination with the adhesive dip in order that the adhesion in the tire be satisfactory. This again is where the finish is involved. A good finish for adhesion will be one which allows rapid penetration of the adhesive into the cord for a satisfactory volume of pickup and one which also allows the dip to reach the cellulose itself so that it may bond to it. Actually, it is somewhat difficult to characterize adhesion very precisely on laboratory tests. Factory processing is needed.

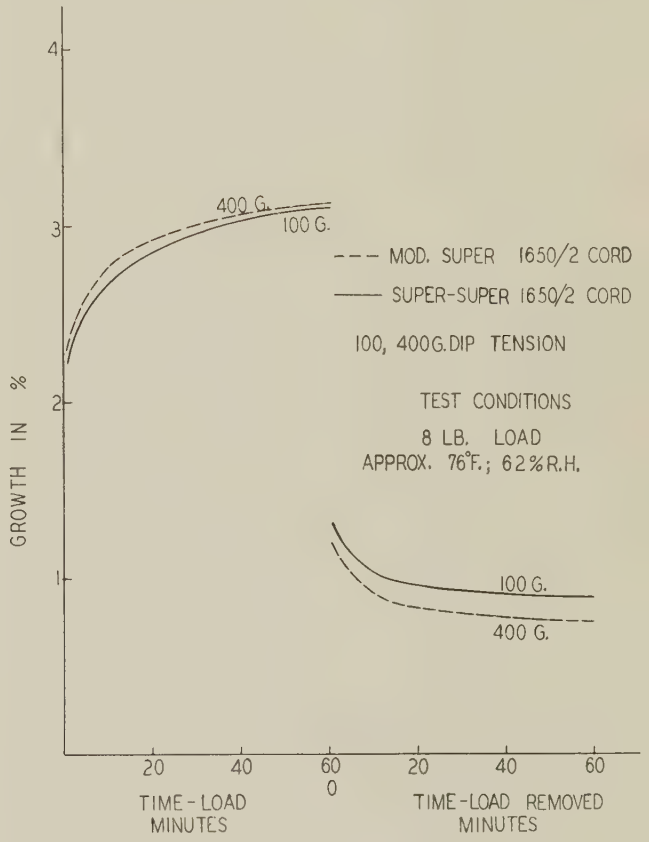

Fig. 8. Growth and recovery of RFL dipped rayon

Uniformity and Extent of Adhesive Pickup

Uniformity is desirable on general principles and one would like a dipped cord to show a uniform coating of adhesive. This coating is partially penetrated into the cord and one would also like to see a uniform degree of penetration. One theory of adhesive pickup, and one which, if not completely true, will at least prevent trouble, specifies that the rayon cord should be penetrated to the extent of three to five filaments. The cord should not be completely impregnated, at least with the same dip which is going to do the adhering. This specification allows the inside of the cord to have a mobility and flexibility and confines the adhesive to the outside of the cord where it can do some good. Resorcinol-formaldehyde-latex dries and bakes to a

rather stiff material which could stiffen the whole cord if it were completely impregnated. But even if the adhesive is confined entirely to the outside of the cord, too high a quantity can also cause the cord to have a stiffness which may damage it during use.

Figure 10 gives an idea of a well controlled pickup and where the adhesive should be placed so as to prevent cord stiffness. The amount of penetration is if anything on the low side.

CHARACTERISTICS WITH CLOSER REFERENCE TO PERFORMANCE

Adhesion

The best tire cord cannot perform unless it adheres to the rubber of the tire and so one might start with adhesion when it comes to discussing performance.

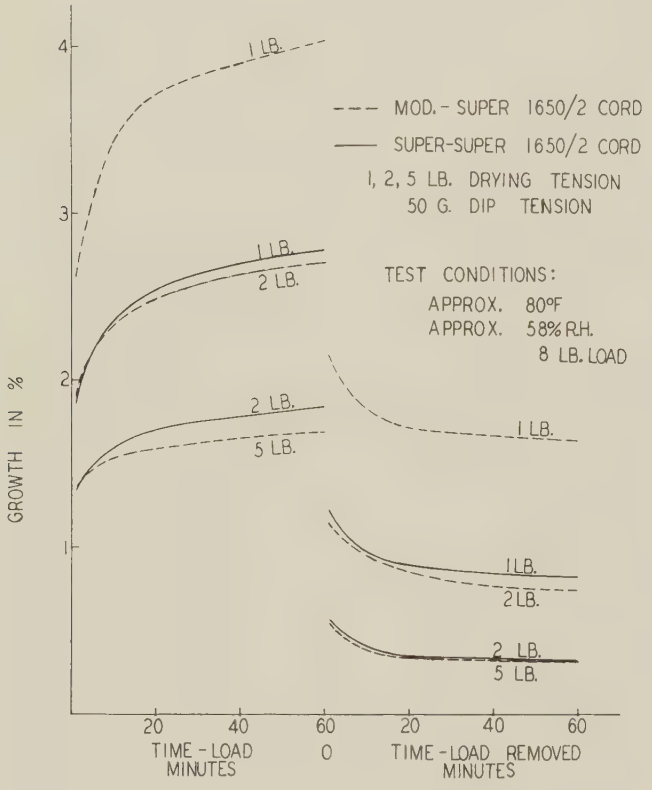

Fig. 9. Growth and recovery of water dipped rayon

As mentioned before, adhesion of rayon to rubber cannot come naturally. Furthermore, the adhesion of the tire cord to rubber cannot be the adhesion of a postage stamp or of a pressure-sensitive tape. The adhesion must approach the cohesion of rubber itself, or that which would be obtained if one imagined the outside filaments of the cord to consist of rubber.

Cellulose is a hard polar substance and rubber, a soft hydrocarbon. The two have little in common. However, this is actually what makes it possible for a very strong adhesive bond to be formed. A remarkable material known as RFL was developed to obtain adhesion. To reach an explanation of why RFL works so well, one considers that it is a mixture of two materials. One of these, resorcinol-formaldehyde resin, has the ability to adhere strongly to cellulose and other polar materials, and the other is rubber latex, which has the ability to adhere to rubber. Both components have the ability to mix with each other and form a fairly intimate combination. It is known that resorcinol-formaldehyde will reinforce (*9*) a latex film to improve the strength. This indicates some sort of physico-chemical or chemical combination. To reiterate, the adhesive can, therefore, be pictured as a mixture of

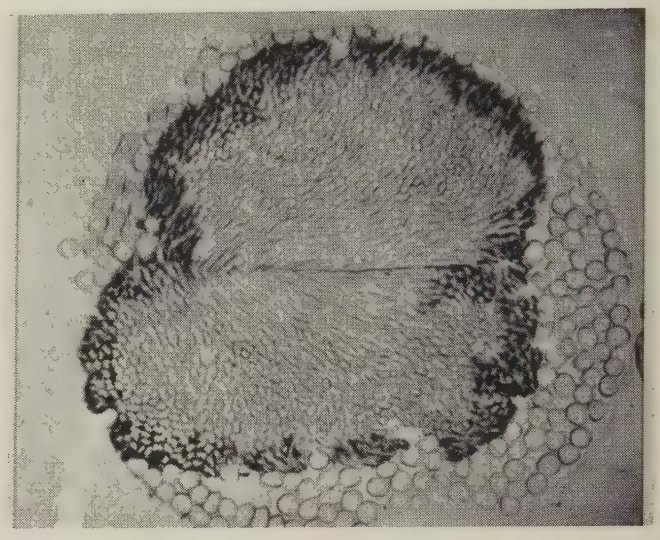

Fig. 10

a polar resin and a rubber latex and within this mixture are binding forces. The polar-resin part of this combination has the ability to adhere to the polar surface of the cellulose and the latex portion of the combination has the ability to cure to the rubber coat. The binding forces between the resin and the latex rubber thus link the cord to the rubber.

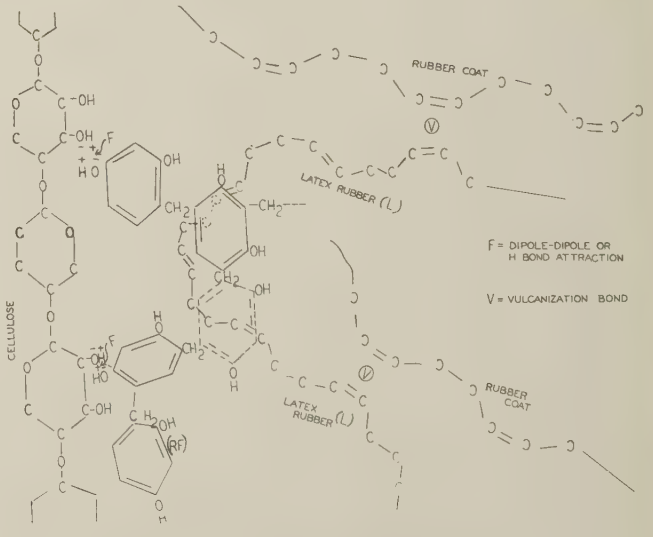

Fig. 11. Rayon-RFL adhesion scheme

Figure 11 pictures schematically the adhesive bond. At the surface of the cellulose, the resin adheres through dipole-dipole or hydrogen-bond forces. Proceeding on toward the rubber, one has a mixture of resin and latex

rubber with in which are some binding forces already mentioned. Finally, on reaching the rubber coat, there is a binding by vulcanization between the rubber coat and the latex rubber.

As mentioned before, the rayon finish can affect the adhesion. If the adhesive must contact the cellulose directly, any oil or waxy material coating on the cellulose fiber will tend to prevent this. This adhesive bond must withstand forces which tend to shear the tread from the carcass, namely, stresses which occur in the plane of the fabric ply, and must also withstand separation forces which occur as the result of the cord being compressed along the longitudinal axis as in the Disk Machine already discussed. In the latter case, the separation results from a bulging-out of the cord and a displacement of one cord ply with respect to the other.

These separations occur most readily when the tire runs hot and, just as the properties of both the rubber and cord are not as good at elevated temperatures, so in a similar way does the adhesion fall off.

Although good adhesion is a prime necessity, it is still hard to predict how much adhesion is needed in a tire. Up to a certain level of adhesion, the tread can be separated from the cords during performance. However, after one reaches this level of adhesion, high speed or high temperature performance will be determined by the properties of the rubber compound and the tread separation, for example, will involve a shearing of rubber stock some distance from the cord rather than off the cord itself. This is sometimes hard to analyze in a tire test. The failure can start within the rubber compound but may propagate to the cord surface, cause a considerable amount of separation at this cord surface, and show a bare cord condition upon analysis.

But one should not count on the lack of need for super adhesion in the tire. One cannot predict when the actual failure may be chased down to the cord again, and when some peculiar type of service may bring forth the need for better cord-to-rubber adhesion.

Tensile Strength and Fatigue Resistance

A certain amount of tensile strength is needed to hold the air pressure that supports the load. Tensile strength is also needed to withstand overloads and to resist the bruise-type break. Tensile strength must be good under conditions of high temperature, particularly in truck tires where flexing and overload may cause the tire to run very hot. A tire cord must have good hot tensile strength and rayon tire cords fulfill this requirement. Other aspects of tensile strength have already been discussed.

A rayon tire cord must have fatigue resistance. It must be able to withstand the flexing which tends to break down the cord in the shoulder region of the tire and perhaps at some point farther down the sidewall. The tire cord in the shoulder region of the tire or down on the lower sidewall can receive a compression type of stress during flexing. This is the type of stress discussed in connection with the Disk Machine. To resist this type of stress, the cord must have a flexibility or lack of brittleness. It must also be twisted into a structure which itself is flexible. A tire cord is a springlike structure. The higher the twist, the more it is like a spring and the lower the twist, the more it is like a rod. The flexibility can also be effected by the applied adhesive. Resorcinol-formaldehyde-latex having a resin as one of its components can produce a stiffening action on the cord. This stiffening action can make the cord into a more rodlike entity which can more readily buckle and concentrate compressive stresses during flexing.

Resiliency

Although in practice it is difficult to analyze, the factor of resiliency should be an important one in a rayon-tire performance. If the cords are not resilient, some of them may acquire changed properties as the result of a sudden or prolonged stress in one portion of the tire. Should a tire receive a sudden jolt as from hitting a stone or should the tire stand in one spot under a high load for a prolonged time, the cords in a local region will be stretched more than in the rest of the tire. If the cords are not resilient, the particular cords of this region must receive a permanent set and

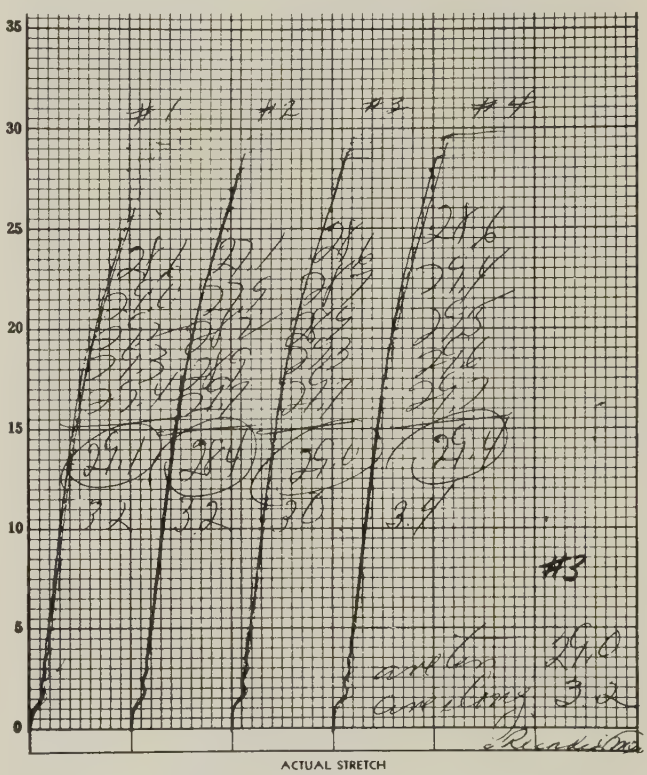

Fig. 12. Stress-strain curves of cords from tire, showing slackness at the origin

also develop the condition of having a higher modulus than their neighbors. In other words, they have been pulled down to a lower stretch condition. One can imagine now that in future performance these particular cords carry a greater share of the load of the tire. Under conditions which would promote fatigue, such as a lower inflation pressure or a high overload, the tire might receive a sidewall break in these particular cords. Therefore, one can imagine that the best rayon

tire will be one prepared with cords that will not readily develop a permanent set, namely, cords which are resilient.

Figure 12 shows the stress-strain curve of cords which one might imagine being able to produce the difficulties just outlined. It can be seen that these cords have a slackness at the lower part of the stress-strain curve. Previously, a stress-strain curve for a cord which had been laboratory dipped and dried in a relaxed state was discussed. The latter case is a similar situation but in the latter case the cords were taken from a tire. That this slackness is not a necessary occurrence is shown by the stress-strain curve of other cords (see Fig. 13). Both sets of cords have

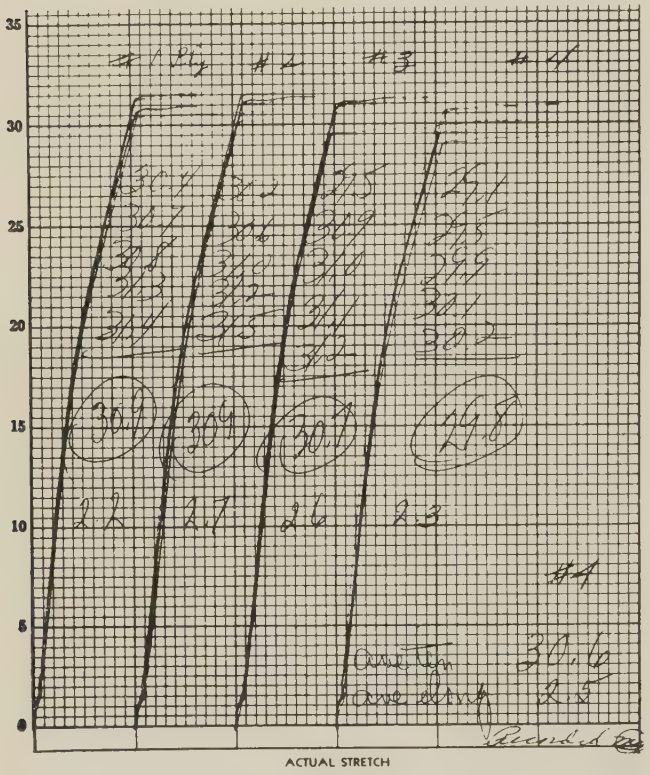

Fig. 13. Stress-strain curves of cords from tire, showing better condition at origin

been removed from new tires and tested in an oven-dried condition. As indicated, this particular slackness has probably been the result of the cord being dipped at low tension, allowed to shrink, and having been dried in this shrunken condition. These are cords which do not have a Hookian stress-strain nature near the stress-strain curve origin and are cords that will be subject to high permanent set. It is this type of cord which, if subjected to a high local load, could change in character compared with its neighbors.

Thus, it has been indicated how bad processing can reduce resiliency. Previously, it was shown that going in the right direction in the matter of drying tension can improve resiliency. It was also indicated that better resiliency can be built into the fiber.

One can observe that there has been a trend in the industry toward processing cords in a tight rather than in a slack condition. In the earlier days of rayon, there was a considerable amount of equipment which could not withstand very much tension and a considerable amount of fabric was run rather loose. In other words, the cords were actually shrunk during dipping. However, in more recent years, this situation has been changed and there has been a tendency to pull down the cord and remove the stretch. The reasons that are given for doing this are not always the same. One tire company will apparently have an entirely different reason than another. Nevertheless, the result is the same as far as our theory on resiliency goes and, undoubtedly, rayon tires have been improved as a result.

Uniformity

A condition of nonuniformity has just been discussed where a hypothetical nonuniformity was produced during the operation of the tire. It should also be possible to have nonuniformity that is built right into the tire. If all cords have not been tensioned identically during processing, one will have this situation. Nonuniformity should also be most dangerous when the cords have been processed in a slack condition.

Separation

Separation has already been discussed in connection with tire cord adhesion, but, as already mentioned, separation is not necessarily due to cord adhesion failure and there are probably more cases where it is connected with failure within the rubber stock itself. It is promoted by hot running. When a tire runs hot, the rubber stock is weakened. It may even tend to revert; i.e., devulcanize.

The answer to this problem is a cooler-running tire, a tire which can distribute stresses more evenly, and perhaps a more resilient cord. The present super-super 1100/2 should go a long way toward fulfilling these requirements. Its lower gage, particularly when we consider the separation problem as one connected mainly with passenger tires, should give a thinner tire and, therefore, a cooler-running tire.

A thinner carcass is also one which spreads the stresses more evenly over the tire and so the new 1100/2 cord should help to achieve this. The most resilient material which should be represented by the super-super form is going to maintain a better condition of uniformity in the tire and uniformity is a wonderful thing for improving high-speed performance.

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The Evaluation of Fibers for Insulating Board—A New Approach

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The various physical properties of insulating board are discussed in relation to the length, fineness, cohesiveness, wet flexibility, and intrinsic strength of its components. Of these, length, fineness (slenderness), and cohesiveness of the elements are the important properties and these are discussed in detail. Because a board is a three-dimensional structure, rather than two-dimensional like paper, for which these variables have been previously studied, further experimental work is needed. The use of viscose fibers of widely different deniers and lengths, bound together with various quantities of beaten pulp, with which to make test boards, is suggested as a simple and straightforward way of ascertaining the desired relationships, which presently can only be inferred by analogy. Such data would be most valuable, not only to characterize new materials, but also to improve means for preparing the stock for boards.

In the literature of the past few decades concerning the evaluation of raw materials for low density structural boards, the available test methods have been few and mainly empirical. The normal procedure has been to make test boards from the materials by simulating practice as far as possible, and then to test them, usually for modulus of rupture at some arbitrary density and thickness; and determine their running qualities by their drainage rate or freeness. Apart from water resistance, which is almost wholly influenced by the sizing agents added, other usual tests comprise deflection of the specimen at the moment of transverse rupture, deflection of the specimen under a given transverse load, tensile strengths parallel to, and perpendicular to the plane of the board, and lineal expansion between dry and moist atmospheric conditions.

THICK AND THIN STRUCTURES

In some ways the problem of fiber evaluation for soft boards may be simpler than for paper pulp because the use requirements are usually fewer. On the other hand, papers are essentially two-dimensional structures, but boards, three. The added dimension introduces a very big question mark when translating findings that apply to papers to thick, soft boards. However, in many respects, the substantial thickness of the boards simplifies an experimental approach toward determining how the properties of the individual fibers influence the structure as a whole.

Largely owing to the development of new test procedures during the last few years, the author has devised a frame of reference that has been applied with considerable practical success to pulps for papers. It is composed of a set of fiber characteristics that were chosen to be as independent as possible of each other and to be adequate in kind and number to constitute a frame of reference, sufficiently comprehensive, to enable the required papermaking and paper properties to be predicted.

For paper, the tests selected are: 1. Fiber length (weight–average length, *not* number average length). 2. Fineness or slenderness of the fibers (weight of a fixed length of fibers laid end to end). 3. Fiber cohesiveness (regarded as the product of the area in mutual contact and the intensity of the cohesion). 4. Fiber flexibility when wet (as measured by the compactness or density of paper sheets made from the fibers under standardized conditions). 5. Intrinsic fiber strength (ultimate breaking strength). 6. Response of the fibers to beating. Without experimental evidence to the contrary, we may assume that with some modifications, the same set of characteristics could be applied to water-laid structural boards; this we shall attempt to do.

It is well to stress the fact that in the transition of experimental findings from a two- to a three-dimensional structure, many assumptions are involved, so that conclusions should be regarded as hypothetical only, until they can be verified by actual experiments. As we shall see, such experiments for soft boards may be easier to carry out than for paper. Also, although it is possible to make thick boards with their outer laminae especially designed to resist compression and tension and their interiors designed to resist shear stresses, in this discussion homogeneous boards will be assumed.

Structural boards, like paper, usually have their basis weight determined in advance. Unlike paper, however, whose wet-pressed thickness is variable (the final thickness being controlled by calendering), structural boards have their wet-pressed thicknesses predetermined. This in effect, predetermines that important characteristic, the density of the resulting structure.

It might be well at this point, to stress the fact that the density with which we are concerned is that of the structure after having had a standardized, fixed pressure applied to it while still wet, and not to the density of the structure after having been subsequently pressed or calendered dry. Except to make it thinner, the latter operation has no appreciable effect of those characteristics of the structure which we shall here consider in detail.

SHEET DENSITY

In the case of pulps for paper, a measure of standard sheet density is one of the most valuable of tests. It also makes the best basis of comparison of the properties of a pulp as it is beaten or of two different pulps.

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Actually, this is common practice in the insulating board industry since the qualities of boards are invariably compared at the same thickness and weight per 1000 sq. ft., i.e., at the same density.

It has been amply confirmed that in the case of thin fibrous structures, if the final density is varied by varying the pressure applied while the sheets are still wet, the tensile strength of the sheets is directly proportional to their final densities, after drying the sheets in a standard manner. The results of one experiment, where an unbeaten, bleached, West Coast hemlock, sulfite pulp was used to make 60 g. per sq. m. sheets, are given in Table I.

Table I. Effect of Apparent Density on Paper Properties
Sheet Density Varied by Wet Pressing

	Unpressed	*Std. pressure*	*Extra pressure*
Density, g./cc.[a]	0.298	0.530	0.775
Density, lb./cu. ft.	18.5	33	48
Tensile B.L. (m.)[a]	825	1750	2370
Klemm Test (lateral absorbency), mm.	140+	81	44
Rigidity Factor (Clark), T 451 m	3.45	36	118

Sheets made and tested in accordance with TAPPI Standards T 205 m (also with different pressures) and T 220 m.

From Table I the rigidity factor, which is proportional to Young's modulus, is strongly dependent on the density, varying with about its 3.5th power. The normal tensile strength of the sheets is seen to be about proportional to their density.

If these relationships hold with the thicker board structure as they do with test sheets of paper, then keeping the board thickness constant and increasing the density will result in a marked increase in rigidity but only a small increase in tensile.

FIBER LENGTH

This is the weight average fiber length, as determined with a classifier equipped usually with a series of coarser screens than normally used for paper pulp, e.g., 8, 14, 28, and 48 meshes per inch, each compartment calibrated for the length of the retained fibers and the results calculated in accordance with TAPPI Standards T 232 m and T 233 m. Coarser screens than for paper fibers are recommended, since it is important for accuracy not to have the percentage of the longest fibers much greater than about 20.

Suppose we have 100 lb. of uniformly long fibers; each with a length of 10 mm. and into it we mix $^1/_2$ lb. of uniformly short fibers, each with a length of 0.2 mm. and one quarter of the coarseness of the long fibers. There would be the same number of fibers in the 100 lb. of the long fibered, as there were in the $^1/_2$ lb. of the very short-fibered material. What is the effective fiber length of the mixture? Is it $(10.2)/2 = 5.1$ mm., as the calculated number average length would show, or is it $(100 \times 10) + (^1/_2 \times 0.2)/100.5 = 9.96$ mm. as the calculated weight average length would show—a reduction of about 0.5% caused by adding 0.5% by weight of short, fine material as from the white water recovery system? Clearly, we cannot halve the length of 100 lb. of long fibers by dumping in a bucket of white water. Nevertheless we continually see number average fiber lengths quoted in the literature. This is one reason why fiber lengths measurements usually have been regarded in the past merely as incidental tests whereas in fact, length obviously is an important fundamental fiber property.

Unfortunately also, most previous experiments dealing with the effect of fiber length, have been obscured not only by employing the number instead of the weight average length, but perhaps even worse, the results have been badly distorted, and in some instances reversed, by the fact that with all naturally grown fibers of a given species, the shorter fibers are also almost invariably the more slender ones. Indeed this also holds true for coarser fibered pulps prepared mechanically from wood. Since, as we shall show, the slenderness of the fibers has a more profound effect on the structure that they compose than does their length, many effects attributed to changes in fiber length were actually caused primarily by a concurrent change in fiber slenderness.

For the following data, special techniques were employed to insure that fiber length was the only variable. Cut viscose fibers were used; also, only the long-fibered portion of a Western Hemlock, bleached sulfite which was made into pads, dried, cut into strips with a razor, and reclassified. The results in Tables II or III for the unbeaten pulp are of interest to the manufacture of structural boards, but it must be remembered that they were determined from thin sheets weighing about 60 g. per sq. m.

Table II. Effect of Fiber Length in Thin Sheets Made from Unbeaten Western Hemlock Bleached Sulfite Pulp

	Long	*Medium*	*Short*	*Very short*
Weight average fiber length, mm.	2.78	1.50	0.73	0.52
Breaking length (tensile), m.	660	470	330	340
Air resistance, sec./100 cc.	0.17	0.16	0.17	0.22
Rigidity factor—Clark (TAPPI Std. T 451 m)	7.2	4.4	3.6	3.1
Wet specific volume,[a] cc./g. (dry)	18.7	17.6	14.8	13.5
Freeness—Can. Std., ml.	750	755	760	735
Apparent sheet density, g./cc.	0.458	0.455	0.451	0.455
Apparent sheet density, lb./cu. ft.	28.5	28.4	28.1	28.4

[a] Volume after draining the pulp in the equivalent of a small Erlenmeyer flask with a wire mesh bottom.

From the above and other work in general, the author has found (*1*) the tensile strength and Young's modulus, other things being equal, are directly proportional to the square root of the weight average fiber length.

Because in the case of thick, lightly pressed boards, many fibers lie at an angle to the principal plane of the structure (see (*2*) for photomicrographs of cross sections of several different kinds of boards), it is likely that the effect of fiber length on tensile or on Young's modulus will be no greater and probably will be less, than for thin sheets. This implies that other things being equal, one would very likely have to use fibers at least four times as long to get a board twice as rigid or twice the tensile strength or twice the modulus of rupture.

Table III. Effect of Fiber Length on Thin Sheets Made from Viscose Silk with 25% Locust Bean Gum plus Alum Added

	Very long	*Long*	*Medium*	*Short*	*Very short*
Weight average fiber length, mm.	4.0	3.36	3.0	2.0	1.75
Breaking length (tensile), m.	1430	1450	1340	880	840
Rigidity factor—Clark (TAPPI Std. T 451 m)	10.0	7.8	8.6	6.3	5.5
Apparent sheet density, g./cc.	0.248	0.257	0.277	0.283	0.290
Apparent sheet density, lb./cu. ft.	15.5	16.0	17.3	17.7	18.0

In the range used for papermaking, fiber lengths appear to have very little effect, if any, on the density of the resulting sheets, given a standard pressing and drying procedure. For example, a change of 5 : 1 in the weight average lengths in Table II appear to produce a change in the sheet density of only about 2%. For longer fibers, as used for soft boards, the indications are (from Table III and elsewhere) that fiber length would have a more substantial effect on density, but still only a minor one as compared with fiber slenderness.

From other data, it was found that when a weight of uniformly long fibers was mixed with an equal weight of uniformly short fibers, the tensile strength of paper made from the mixture was exactly in accord with the tensile strength of paper made by another fraction of uniform fibers having the same weight average length as the mixture. This important finding probably holds for thick structures, too, and implies that if the weight average length is calculated, it is not important to know the distribution of fiber lengths in the furnish.

As is well known, fiber length has an adverse effect on evenness of formation. This is because the longer the fibers, the more likely they are to come into contact with other fibers within the suspension, and thus more liable to form clots. Fibers in a dilute suspension can turn about in any direction, so that each could occupy the volume of a sphere, the diameter of which is a fiber length. Thus the chances of one fiber touching another, in a very dilute suspension, is proportional to the cube of their lengths. In a more concentrated suspension, the clot-forming tendencies would be in proportion to a lesser power, possible the square. In any case, since fiber length has such a pronounced adverse effect on the uniformity of formation of a fiber structure; this to a degree detracts from the extra strength conferred by the greater length.

FIBER FINENESS

It is only recently that a practical test for this property became available (*3*). Since the flexibility of a rod is proportional to its moment of inertia which, in turn, depends on the fourth power of its diameter (or the difference between the fourth powers of its inner and outer diameters if it were hollow) and if the diameter of a fiber were reduced by only 16%, theoretically, its flexibility would double. The number of fibers in a cross section of a fibrous structure depends inversely on the square of the fiber diameter, and the compacting force of surface tension, as the water leaves the sheet, is 140 dynes per centimeter of fiber length irrespective of fiber thickness. Accordingly, a reduction in average fiber diameter only by about 11%, theoretically, would cause a drained wet sheet of the pulp to be only one half its unpressed moist bulk. This would happen only if (a), the elements are uniformly thick (b), they are fine enough to be drawn together by the surface tension of the water and (c), the fibers have no spring back after the water leaves. Consequently in practice, with a structural board, nowhere near this contraction could be expected to occur; nevertheless it would be substantial.

An increase in the average slenderness of the component fibers of a structure would have a number of important effects:

(1) The density of the structure would increase, unless it were pressed to a constant thickness, when less pressure would be used.

(2) The areas of contact of the components would increase but the pressures at the contact points of the moist sheet would be less during pressing.

(3) The flexibility of the fibers would increase so that an applied breaking load to the finished board would be distributed over a greater volume of its structure. It would thus not only be stronger but would also have more stretch and so would be much tougher.

(4) The interstices between the fibers would become smaller and, since the flow of water through capillaries is proportional to the 4th power of their diameter, the slowness of the stock would greatly increase because it would be much harder for the associated water to drain away.

(5) The clotting tendency of the pulp in suspension would be greater.

(6) The surface of the board would be smoother.

The increase of contact area and the fineness of the fibers making the sheet tougher, would both increase the modulus of rupture. However, an adverse factor under certain conditions would be that less pressure would be required when the sheet is wet to reduce it to the specified thickness. The higher this pressure the more intense would be the contact pressure at the crossover points of the individual fibers in the structure and hence the stronger their cohesion would be.

COHESIVENESS

The cohesiveness of the fibers depends on their area in mutual contact and the intensity of the cohesive force. The cohesive force is very small in the case of raw wood but improves markedly with chemical treatment, especially with heat. If the fibers are in a liquid, both chemical treatment and heat serve to remove part of the lignin from the surfaces of the fibers. This permits the cellulose in the fibers to be better exposed and thus allow the fibers to form stronger mutual bonds. It is not believed that the lignin present is of much, or indeed, of any use for bonding the structure together. All the bonding effect is thought to be due to the mutual adhesion of microfibrils and molecules of cellulose which spontaneously arise when natural cellulose surfaces are wetted with water and especially if they are at least slightly rubbed. The water and friction causes

the microfibrils and molecules to be raised up from the cellulose surfaces like, on a several million-fold scale, grass growing on the bottom of a pond. When the water finally drains away the cellulose molecules and fibers on adjacent surfaces are firmly drawn together by very powerful pressures due to surface tension and are joined by hydrogen bonds.

In the case of board stock, it is possible that the best measure of cohesiveness is made by following the technique developed by the author for paper pulp (*4*) namely, by pressing two fibrous sheets made from the fibers together while wet (perhaps two pads from the SMFC drainage tester (*5*) could be used), and then measuring the force required to separate them. In the case of fiber boards this can be done conveniently by measuring the transverse tensile strength of the laminate so made. Another possibility for measuring the cohesiveness is a modification of the shear test used for the bonding of plywood, recently described in a modified form for testing hard board (*6*). It comprises making two parallel saw cuts about 1 in. apart, one on each side of and across the two opposite faces of a 2-in. wide strip of the board specimen, the cuts going about half way through the thickness of the strip, then gripping the ends of the strip in a tensile tester and measuring the load required to shear the area of the board between the saw cuts.

The force required to separate a lamina of the board will include both the area in contact and the intensity of the cohesive force. A measure of the latter is obtained by dividing the tensile stress needed to separate the lamina by the density of the structure.

Except when the fibers in the board are all parallel to the surfaces, the resistance of the structure to separation, when a transverse tensile stress is applied, will depend not only on the cohesiveness but also upon the length and the fineness of the fibers. This is so because the real function of cohesivesness is not that of providing a direct resistance to a disrupting load, but primarily that of providing an adequate degree of friction to the individual fibers lying across the zone of fracture to prevent them from being pulled out of the body of the board as the structure is broken. As has been discussed, the resistance of an individual fiber under tension embedded in a thin sheet would appear to be proportional to the square root of its length. This resistance would also be some function of its slenderness, since the more slender the fibers the better distributed would be an applied stress, consequently the stronger and tougher would be the structure. Their resistance to being pulled out of place would also be affected by the density of the fibrous mass; probably directly proportional to it.

FLEXIBILITY WHEN WET

If the fibers are of raw wood and of constant diameter, then both their dry and their wet flexibility will not be very different, because, as has been shown (*7*) the modulus of elasticity of most woods, divided by the density of the wood, is fairly constant. Cooking or chemical treatment, however, would increase their flexibility but scarcely to the same degree as would a reduction in their diameter, since the latter affects the fibers in proportion to the fourth power of their diameters.

Probably the main effect of increasing the wet flexibility of the fibers, besides increasing the wetness of the pulp, is to require less pressure on the wet mat to reduce it to the desired thickness. This will lessen the stress squeezing together the area of fibers in mutual contact, and in this respect, promote a degree of weakness.

Since the flexibility when wet is largely a function of the average fiber diameter or fiber slenderness, which we presume we have already measured, and in the case of soft boards, the structure is pressed to a given thickness irrespective of the wet flexibility of the fibers, its intrinsic measurement is not normally important except perhaps as a good measure of its drainage quality. However a fair measure of wet flexibility could be obtained with a metal cylinder of about 2 in. diameter and weighing about 5 lb., suspended axially from the end of a thin rod and placed centrally on the residual pad of pulp in the SMFC drainage tester. By means of a scale on the rod and a cross piece placed across the top of the drainage tester, it would be possible to measure accurately the thickness of the wet mat under a compression equal to say, 36 in. of water provided by the cylinder, and thus calculate its wet specific volume under that pressure.

INTRINSIC FIBER STRENGTH AND BEATING

The intrinsic strength of the fibrous elements is probably so high, and sufficiently constant for various woods if corrected to a given density (*7*) that it is not an important variable for soft boards. If the fibers were as fine as paper pulps, their intrinsic strength could be

Table IV. Possible Influence of Various Fundamental Characteristics of the Raw Material on the Properties of Soft Boards

	Fiber length	*Fiber slenderness*	*Cohesiveness*	*Intrinsic flexibility when wet*	*Intrinsic strength*	*Density of structure*
Modulus of rupture	+2[c]	+3	+3	−1	+1	+3
Tensile strength parallel to surface	+2	+3	+2	−1	+1	+2
Tensile strength perpendicular to surface	+1[b]	+2	+3	−1	0	+2
Minimum deflection at transverse break (stiffness)	+3[d]	+3	+3	0	0	+3
Maximum deflection with load (suppleness)	+1	+1	+3	−1	0	+3
Resistance to expansion with moisture	+1	+1	0	0	0	−2
Thermal insolation	0[a]	+1	0	0	0	−1
Sound absorption	0	−1	0	0	0	+1
Water absorption	0	−1	0	0	0	−1
Slowness of stock on machine	0	+3	0	+3	0	

[a] 0—No appreciable influence.
[b] 1—Weak +ve or −ve influence.
[c] 2—Moderate +ve or −ve influence.
[d] 3—Strong +ve or −ve influence.

measured after making into sheets and using the zero span tensile jaws. For coarse fibers of a homogeneous character, this property could be better measured by taking several of the bigger individual fibers, and obtaining their tensile strengths and their cross sections at the point of breakage.

With raw or semiraw fibrous elements normally used for making insulating boards, beating or refining serve mainly to reduce their dimensions, and these properties already have been considered.

CONCLUSIONS

Table IV gives some guesses at the magnitude of the influence of the various characteristics discussed on the more common properties of soft boards. If it were possible to substitute in that table, instead of the estimates indicated, an exact statement of the relationship in each case, i.e., that the tensile strength was proportional to the "*n*th" power of the fiber length and the "*m*th" power of the fiber coarseness, etc., one would possess a powerful tool, not only to characterize a new fibrous material, but also to improve the treatment of a presently used material to make a better board.

It is suggested that an interested group might arrange to procure from a rayon manufacturer, four or five samples of viscose yarn of increasing denier but the same quality, cut the strands of different thicknesses into a series of portions having uniform but different lengths; add various quantities of highly beaten, sulfite pulp to serve as a binder; form the various mixtures into boards and test these for the properties shown in Table IV. This would not take an inordinate amount of time nor be very difficult. It is hoped that enough has been said, to show that the resulting information would probably be well worth the effort, since it would provide a much deeper understanding of the nature of the product than we have at the present time.

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Distribution of the Constituents Across the Wall of Unbleached Spruce Sulfite Fibers

OTTO KALLMES

The properties of fibers depend principally on their composition, their physical properties, and on the distribution of the constituents across the fiber wall. The first two factors have been studied extensively, but only a few distribution studies have been made and these were qualitative in nature. A technique has been developed for isolating P-S_1 material and S_2 material from delignified fibers in sufficiently large quantities for chemical analyses. From the analyses of the P-S_1, S_2 material, and the original fibers, it was possible for the first time to approximate the distribution of the constituents across the wall of unbleached spruce sulfite fibers. These distributions are as follows: the concentration of lignin in P and S_1 (about 5.8%) is 10 to 20 times as large as in S_2 (0.4%). The concentration of alpha-cellulose (81.3%) and of the hemicelluloses (12.9%) in P and S_1 are slightly *lower* than in S_2 (82.6–84.0% and 15.5–17.0%, respectively). The distribution of the hemicelluloses is consistent with the distributions of the sugars, glucose, mannose, and xylose, which are present in an essentially constant ratio (29:2:1) across the fiber wall. The D.P. of P and S_1, 2030 is about two-thirds that of S_2. P and S_1 are partially crystalline, but not as much as S_2. Two related experiments were carried out: (1) It was found that unraveled P and S_1 fragments can enhance sheet strength properties considerably. (2) Two theories on the "balloon-type" swelling were corroborated. These theories are that S_1 is primarily responsible for the constrictions observed during ballooning, and that the "skin substance" concept is unnecessary to explain ballooning.

THE characteristics of fibers* depend not only on their composition and on the overall physical properties of the constituents, but to a great extent on the spatial distribution of the constituents within the fiber wall. For example, the strength properties of a sheet of paper are a function of the strength of the bonds between the surfaces of the contiguous fibers. The strength of these bonds is determined chiefly by the composition and the physical characteristics of the outer portions of the fibers. Thus, a knowledge of the constitution and properties of the outer layers is essential to an understanding of the nature of interfiber bonding.

Only a few qualitative studies have been made on the distribution of lignin and the carbohydrates across the fiber wall. The lack of fiber-wall distribution studies is primarily due to the difficulties involved in working with materials of the small dimension and the small mass (10^{-6} to 10^{-7} g.) (*1*, *2*) of individual fibers.

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* The term *fiber* as used throughout this paper refers to untreated as well as delignified longitudinal coniferous tracheids.

There are three general avenues of approach to distribution studies: (1) The distribution of the constituents within the fiber wall can be postulated from the behavior of fibers in controlled experiments. This approach, which was taken by Jayme and von Köppen (*3*), involves considerable speculation. (2) The distribution of the constituents can be studied *in situ* by physical methods. This approach was taken by Lange (*4*) who studied the distribution of lignin and the carbohydrates in the wall of untreated as well as delignified spruce fibers by microspectrographic techniques. The main shortcoming of Lange's techniques is that they give qualitative results. (3) The distribution of the constituents within the fiber wall can be approximated by isolating specific portions of the wall of many fibers and analyzing the isolated materials by chemical techniques. This approach has been applied successfully in the present investigation. Clark (*5*) also used it in an isolation of the "skin substance" (primary wall) of bleached sulphite fibers. Clark's isolation was carried out by a technique which is similar to the one used in this investigation.

It has been known for a long time that fibers consist of four concentric walls which are bonded relatively loosely to each other (*6*). Therefore, it was believed at the outset of this investigation that it should be possible to unravel and isolate in identifiable form specific walls of the fiber. Early in the experimental program it was discovered that the two outer walls unravel simultaneously. These two walls constitute a small fraction of the fiber mass. With this limitation in mind, the following objectives were set for this thesis: (1) To isolate portions of the primary and outer secondary walls (P and S_1) and of the middle secondary wall (S_2) of unbleached spruce sulfite fibers in a definable form. (2) To establish positively by microscopic comparisons the origin of the isolated materials in the fiber wall. (3) To study the structural details and chemistry of the isolated materials.

PRESENT CONCEPT OF STRUCTURE OF SPRUCE FIBERS

Spruce fibers are elongated four-to-six-sided cells which, in the native wood, average 3.3 mm. in length and 25 to 30 μ in tangential width (*7*). Their radial width varies from 25 to 30 μ in early springwood fibers to 5 to 10 μ in late summerwood fibers. The main constituents of the fiber wall are cellulose, the hemicelluloses, and lignin.

On an ontogenetic basis, fibers consist of two concentric walls, the tenuous P and the relatively thick secondary wall (Fig. 1). The P is a thin, loosely woven network of microfibrils which, in untreated fibers, are embedded in a matrix of lignin and hemicelluloses (*8*). The thickness of P is believed to be nonuniform (*9*); values of 0.1–1 μ have been reported for its average thickness (*10*). It is well known from electron microscope studies that the microfibrils of P are interwoven and that they are more or less randomly oriented in a generally transverse direction to the longitudinal fiber axis (*8, 11–13*).

On the basis of microfibrillar orientation, the secondary wall of normal fibers can be subdivided into three concentric walls, S_1, S_2, and S_3. The S_1 is a thin membrane, approximately 0.5 μ in thickness, which contains two sets of fibrils which spiral in opposite senses to the longitudinal fiber axis. The angle between a tangent to either set of fibrils and the longitudinal fiber axis (fibrillar angle) is about 60°.

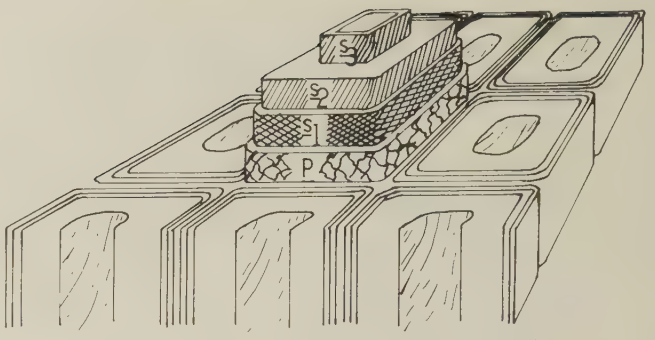

Fig. 1. Wall structure of spruce fibers (2)

The S_2 contains the bulk of the fiber mass. In each growth ring, the thickness of S_2 gradually increases from about 1 μ in the early springwood fibers to over 5 μ in the late summerwood fibers (*14*). The S_2 of untreated fibers contains 75–90% carbohydrates and 25–10% lignin in two continuous, interpenetrating systems, either of which can be dissolved out without seriously modifying the structure of the remaining one (*9, 15*).

According to Bailey (*9*), the lignin and the carbohydrates are not distributed uniformly throughout S_2 of untreated fibers, but are grossly divided into carbohydrate- and lignin-rich layers which form two different patterns, *concentric* and *radioconcentric* (Figs. 2a and 2b). Both patterns are widespread, and in some cases, both are present within a single fiber. The concentric layering, which may consist of as many as 35 cellulose-rich layers in summerwood fibers (*16*) has been reported by numerous investigators (*8, 17–19*). Besides Bailey

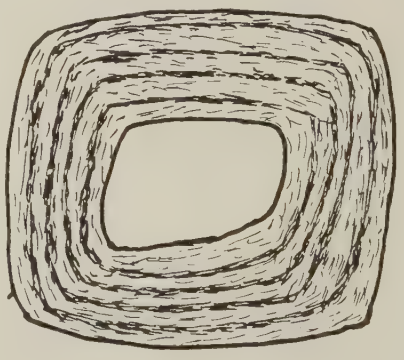

Fig. 2A. S_2 with concentric layering (9)

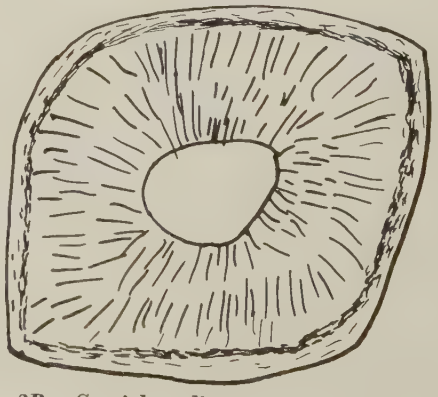

Fig. 2B. S_2 with radioconcentric layering (9)

(*9*), only Wardrop and Dadswell (*20*) have reported radioconcentric layering of S_2.

The cellulose of S_2 forms microfibrils which are oriented parallel to each other and which almost invariably spiral around the longitudinal fiber axis with a Z-form (*2*); i.e., the microfibrils appear to turn clockwise as they recede from an observer looking down the fiber axis. The fibrillar angle of S_2 varies from 0 to 50°.

The S_3 of most species is similar to S_1 in its dimensions and microfibrillar orientation (*2*). A layer similar to S_1 is not present on the inner surface of S_2 of normal spruce fibers and, therefore, Wardrop and Dadswell (*19*) concluded that S_3 is absent from this species. On the other hand, considerable evidence of a thin but unique layer inside S_2 of spruce fibers has been obtained by Bucher (*21*) using specific dyes, and by Meier (*13*) and Asunmaa (*22*) using wood-rotting fungi. These investigators have shown that the innermost layer of the spruce fiber wall has a fibrillar orientation similar to that of S_2.

Few data are available on the overall distribution of lignin and the carbohydrates across the wall of untreated spruce fibers. Lange (*23*) found that the lignin comprises 10–20% of the mass at the lumen, and that it increases only slightly across S_2. He found that the lignin concentration increases from about 20% to about 60% across S_1, and that it comprises 60–90% of P. Lange (*15*) demonstrated that the carbohydrates are distributed more or less uniformly across the wall of Swedish spruce holocellulose fibers. However, the cellulose comprises about 85% of the carbohydrates at the lumen and decreases linearly to about 40% in P. The hemicelluloses, on the other hand, constitute 15% of the carbohydrates at the lumen and 60% of the carbohydrates of P.

EXPERIMENTAL

Isolation of a Portion of P and S_1

Preparation of Reclassified Fibers. The isolation of a portion of P and S_1 was based on the size difference between unraveled P and S_1 fragments and the parent fibers. Therefore, ray cells and miscellaneous pulping debris, which were approximately the same size as P and S_1 fragments were separated from the long, undamaged fibers by the following procedure.

Chips of white spruce [*Picea glauca* (Moench) Voss], carefully screened from sawdust and knots, were pulped by a long, low-temperature calcium-base sulfite cook. The initial composition of the cooking liquor was as follows: total SO_2 = 7.27%, free SO_2 = 6.09%, and combined SO_2 = 1.18%. The maximum cooking temperature was 131°C. and the total cooking cycle 13 hr.

The chips were cooked in a removable basket mounted in the digester in order to eliminate fiber damage that might have been incurred by blowing the digester. The pulp was washed for five 10-min. periods with warm deionized water under gentle agitation. The washed pulp was only partially defiberized, and the residual chips were broken up by hand into individual fibers and small fiber bundles. The fiberized pulp was screened by a flat screen with 0.010-in. openings; the screening rejects were discarded.

The screened pulp was classified in 10-g. batches for 6 min. in the first two compartments of a Bauer-McNett classifier fitted with the 8 and 12-mesh screens. Only the fibers retained by the classifier were treated further.

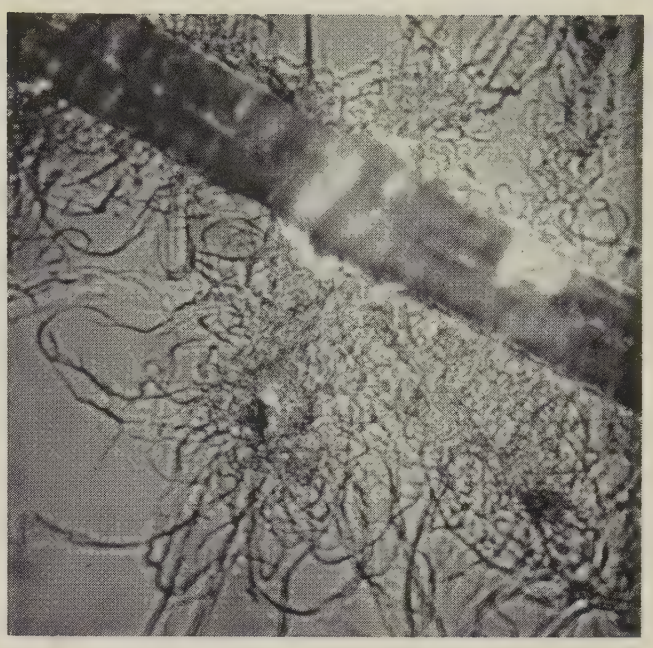

Fig. 3. Reclassified fibers and attached P fragments (440×)

The remaining fiber bundles of the once-classified pulp were broken up in a 20-min. treatment (2500 counts) in a British disintegrator. (The propeller of the disintegrator has a speed of 50 rev. per sec.) A consistency of 1% was used in this and in all subsequent disintegrator treatments. Because a small quantity of ray cells was freed during the breaking up of the fiber bundles, the pulp was classified again under the conditions outlined above. The fibers retained by the classifier at the end of the second classification were equal to less than 10% of the screened pulp, and hereafter they are referred to as *reclassified fibers.* A microscopic examination of the reclassified fibers revealed that they were almost completely free of ray cells, cut fibers, and debris.

Unraveling of a Portion of P and S_1. The walls of the reclassified fibers were unraveled consecutively and randomly from all fiber surfaces by prolonged stirring in a British disintegrator. In the first 12,500 counts

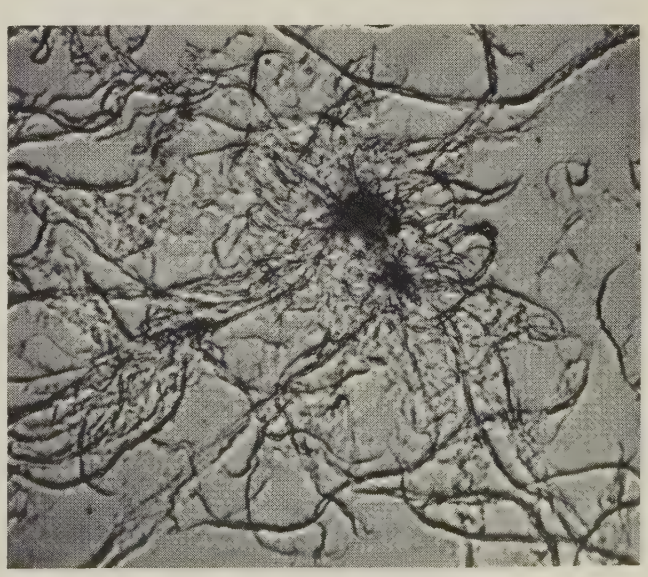

Fig. 4. Isolated P fragments (440×)

(i.e., after a total of 15,000 counts) only P and S_1 unraveled. The material unraveled thereafter became increasingly poor in P and S_1 material and increasingly rich in S_2 material. Unraveling of S_2 is discussed in detail later.

The outermost wall, P, of mechanically undamaged fibers had to unravel first. A small amount of material believed to originate from P was partially unraveled during the preparation of the reclassified fibers; i.e., it was unraveled but remained attached to the fibers (Fig. 3). The material attached to the fiber in this figure is typical of most of the first material unraveled from the fibers. It includes fragments which appear to be membranes composed of randomly oriented fibrils and some individual fibrils. It cannot be proved that these fragments are truly membranous P fragments and that they are not flocculated fibrils. However, these fragments, or their constituent fibrils, originated from P or S_1 for two reasons: (1) Unraveled S_2 material has an entirely different structure. (2) S_2 material is not unraveled until the fibers have been stirred over 15,000 counts.

Figure 4 shows a completely unraveled P fragment similar to the fragments in Fig. 3. Because such fragments unraveled in more or less equal quantities with identifiable S_1 fragments between 3500 and 15,000 counts (see below), fragments similar to the one in Fig. 4 are referred to as P fragments hereafter.

Individual fibrils indistinguishable from those in Figs. 3 and 4 were unraveled along with S_2 material during the later stages of stirring. There is no reason to believe that individual fibrils were removed preferentially from S_2 before the bulk of this wall was unraveled. It is therefore concluded that the individual fibrils unraveled during the first 15,000 counts of stirring originated primarily from P and S_1.

In the stirring interval between 3500 and 15,000 counts, a large quantity of P and S_1 fragments were unraveled. Typical S_1 fragments are shown in Figs. 5 and 7; they are similar in appearance to S_1 fragments obtained by Emerton and Goldsmith (*6*) and by Wardrop (*24*). The S_1 fragment in Fig. 5 appears to have unraveled from the adjacent fiber because it contains pit impressions in mirrored-image positions of pits on the fiber.

Relatively few S_1 fragments were found in which one set of fibrils was partially absent. Therefore, it is concluded that S_1 of *Picea glauca* contains, for the most part, *two* sets of fibrils which have the same fibrillar angle.

Separation of P and S_1 Fragments from 15,000-Count Fibers and Yield Obtained. The P and S_1 fragments were separated from the 15,000-count fibers in the Bauer-McNett classifier run on deionized water. Only the first compartment of the classifier, fitted with the 200-mesh screen, was used. Three-gram batches of 15,000-count fibers were classified for 4 min. The P and S_1 fragments were in the filtrate which was collected; the fibers were retained by the classifier.

The concentration of P and S_1 fragments in the classifier filtrate was less than 0.1 g.p.l. The fragments were flocculated by centrifuging the filtrate for 15-min. periods in an International centrifuge run at 1800 r.p.m. The water above the flocculated particles was siphoned off and the flocs from several centrifuge bottles were combined and centrifuged again. Repeating this procedure numerous times gradually built up the concentration of fragments to several hundred milligrams per 50 ml. About one week was required to concentrate the P-S_1 material from 3 g. of 15,000-count fibers.

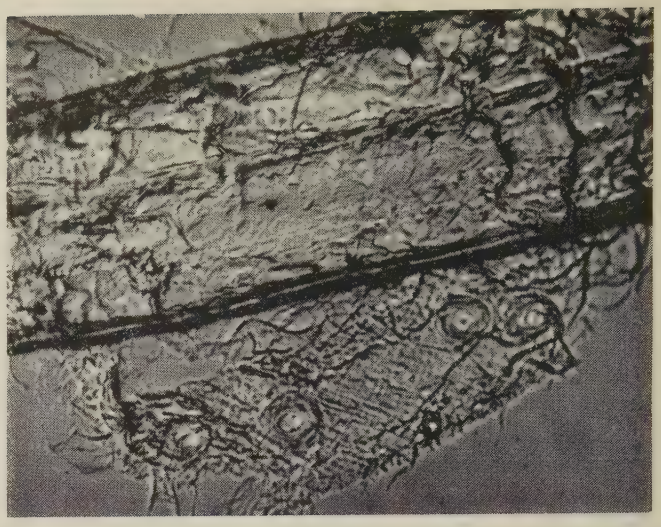

Fig. 5. 15,000-Count fiber and attached S_1 fragment (440×)

The isolated P-S_1 material hornified when dried directly from water and, therefore, the water was replaced by acetone by the solvent-exchange method. The P-S_1 material was dried from acetone on microscope slides in sheet form under vacuum at room temperature. The sheets, each weighing approximately 2 mg., were peeled off the slides with a razor blade.

A yield of 3.3% of P-S_1 material was obtained from the 15,000-count fibers. As P and S_1 certainly contain less than 20% of the fibers' mass, the isolated P-S_1 material represents at least 15% of these walls.

For visual inspection, the P and S_1 fragments were dried on slides directly from the classifier filtrate under vacuum at room temperature.

Evidence That Isolated Material Is from P and S_1. Slides of the isolated P and S_1 fragments were metal-shadowed with chromium by Emerton's technique (*6*)

Fig. 6. Isolated P and S_1 fragments (84×)

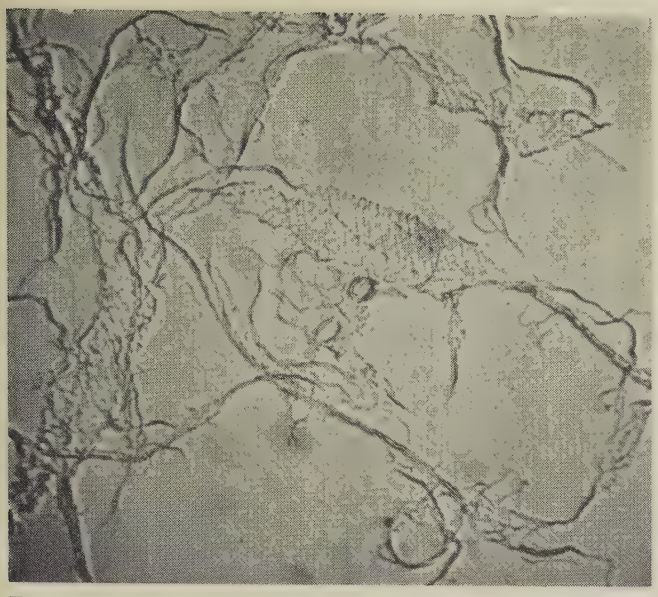

Fig. 7. Isolated S_1 fragments, enlarged from Fig. 6 (440×)

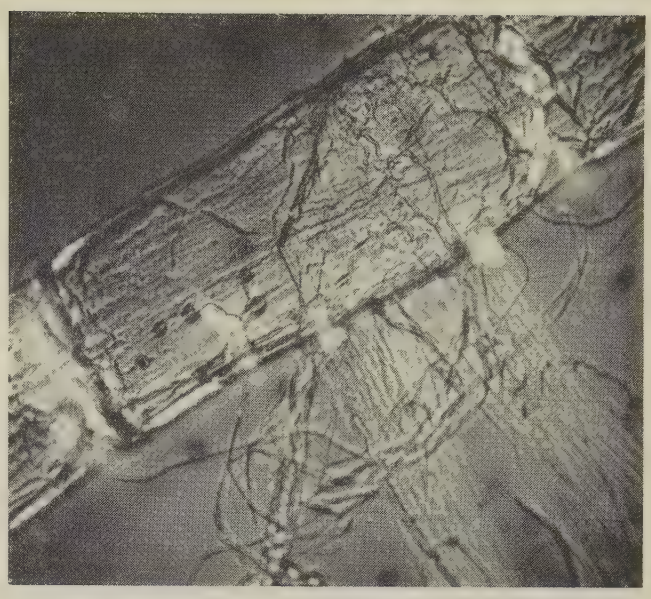

Fig. 8. 300,000-Count fiber and attached S_2 layer (440×)

and examined with a metallurgical microscope. Unshadowed slides were examined with a polarizing microscope. The following observations were made:

1. About one-half the isolated fragments were S_1 fragments and the other half P fragments. Figure 6 is a typical view of a slide of isolated P and S_1 fragments. The structural details of the fragments of this photomicrograph are difficult to distinguish without further magnification and, therefore, two S_1 fragments are shown enlarged in Fig. 7. Figure 6 is presented only to demonstrate that the isolated P-S_1 material contained no unidentifiable debris.
2. No ray cells were present. Had a few undetected ones been present, their mass contribution to the isolated P-S_1 material would have been negligible because their walls are less than 1 μ thick.
3. A negligible quantity of S_2 material was present.
4. All of the isolated material was birefringent. The lack of isotropic material showed that material from the middle lamella was absent (*25*).

It was not possible to determine the purity of the P-S_1 material quantitatively. However, after carefully examining many slides, it can be safely concluded that the P-S_1 material contained less than 10%, and probably less than 5% contamination.

UNRAVELING OF MIDDLE SECONDARY WALL

The reclassified fibers were stirred a total of 300,000 counts in the British disintegrator. The fibers were classified intermittently to remove the unraveled material, thereby making it possible to follow the gradual disintegration of the fibers without their being cluttered by debris.

In the stirring intervals above 15,000 counts, the quantities of P-S_1 material unraveled became smaller and smaller. Above 200,000 counts, only trace quantities were removed from the fibers. It is therefore concluded that the 300,000-count fibers contained essentially only S_2 material.

The S_2 material first unraveled in tiny quantities between 15,000 and 20,000 counts and in increasingly large quantities thereafter. Between 20,000 and 50,000 counts, the material unraveled consisted almost entirely of membranous layers. Beginning at 50,000 counts, whole sections of the S_2 wall were literally ripped out of the fibers.

Unraveling of S_2 in Layers

Unraveling of S_2 in layers is illustrated in Fig. 8. This figure shows a partially unraveled layer still attached to the fiber at a fold which makes an angle of 45° to the longitudinal fiber axis. The faint white line which runs parallel to the fiber axis and to the left from the lower left-hand corner of the fold indicates where the unraveled layer was torn from its layer of the fiber. A single set of fibrils oriented parallel to each other and to the fiber axis is visible both above and below the tear line. From simple geometric considerations, it can be seen that the single set of parallel fibrils of the unraveled layer was also oriented parallel to the fiber axis prior to its removal from the fiber. Because it has been well established that only S_2 (and the disputed S_3) of spruce has this fibrillar orientation, it is concluded that the unraveled layer in Fig. 8 originated from S_2.

Many fibers similar to the one in Fig. 8 were unraveled down to their innermost layers after 300,000 counts of stirring. A fiber of this type whose top layer has been split open and folded back above the fiber is shown in Fig. 9. Here one is looking at the innermost layer of the fiber from the lumen side. The transverse cracks in the upper section were probably caused by shrinking of the fibrils during drying. From the fibrillar orientation of the folded back layer, it is evident that the fibrillar angle of the innermost layer of spruce fibers is small and similar to that of the bulk of S_2. This finding is in agreement with results obtained by Wardrop and Dadswell (*19*), Meier (*13*), and Bucher (*21*).

The unraveled S_2 layers are not basic structural units of fibers (*9*). It is believed that the lignin-rich layers of the untreated fibers, which became relatively porous during delignification, are planes of weakness in the delignified fiber wall (*17, 26*) at which the fibers split preferentially during mechanical treatment. The unraveled S_2 layers are not necessarily single cellulose-rich layers, but may be several which split off as a unit.

Unraveling of S_2 in Sections

It was found that whole sections were ripped

out of the S_2 walls of many fibers after 50,000 counts of stirring (Fig. 10). In most cases, the S_2 wall sections were found torn free from the fibers like the one in Fig. 11.

The bulk of the S_2 wall sections consisted of fibrils of varying diameters. A few long and numerous short, thin S_2 layers were found attached to the wall sections. Their central portion was generally 2 to 3 μ thick, and for this reason it is believed that they originated primarily from summerwood fibers.

The information obtained in this investigation on S_2 wall sections is of a preliminary nature, and without considerably more evidence, conclusions cannot be drawn. However, it is hypothesized by this author that the formation of wall sections can be explained on the basis of the radioconcentric layering of S_2 proposed by Bailey (*9*). It is postulated that the wall sections were torn from the fibers primarily at the radial planes of weakness which were formed by the delignification of fibers whose S_2 had a radioconcentric layering.

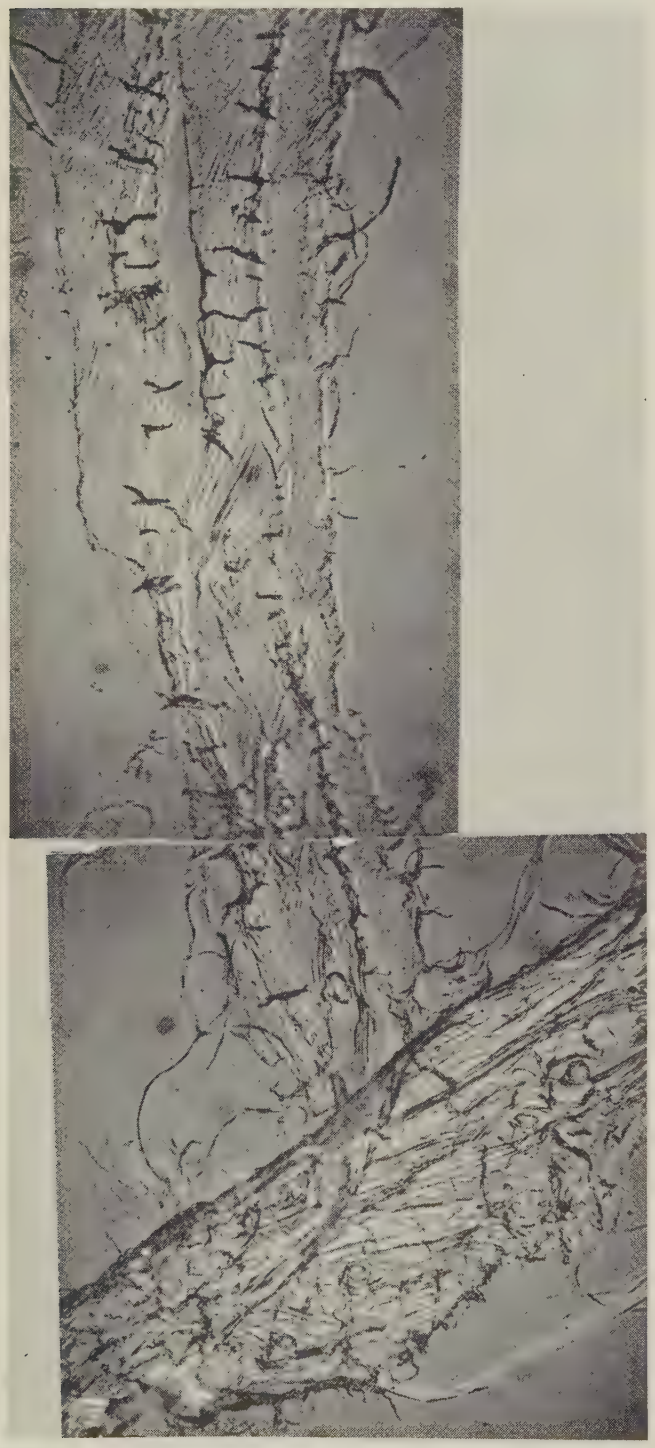

Fig. 9. 300,000-Count springwood fiber with innermost layer seen from lumen-side (440×)

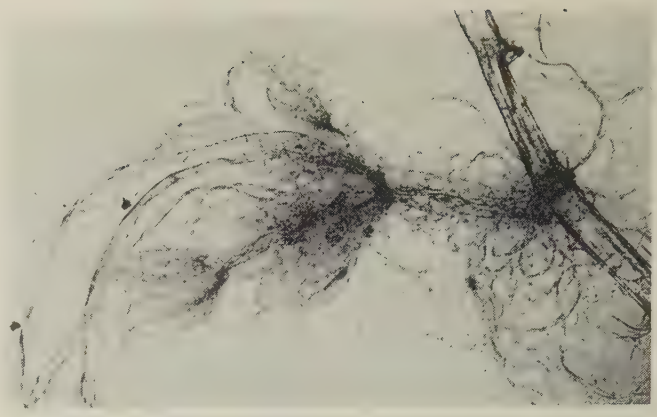

Fig. 10. 300,000-Count fiber and attached S_2 wall section (95×)

EXAMINATION OF UNRAVELED P, S_1, AND S_2 MATERIAL WITH POLARIZING AND METALLURGICAL MICROSCOPES

Metallurgical Microscope

The gross structural details of the fibers and the unraveled P, S_1, and S_2 material were seen most clearly with the metallurgical microscope, especially if the slides were first metal-shadowed (*6*). Most of the photomicrographs for this investigation were taken with a Bausch and Lomb metallurgical microscope.

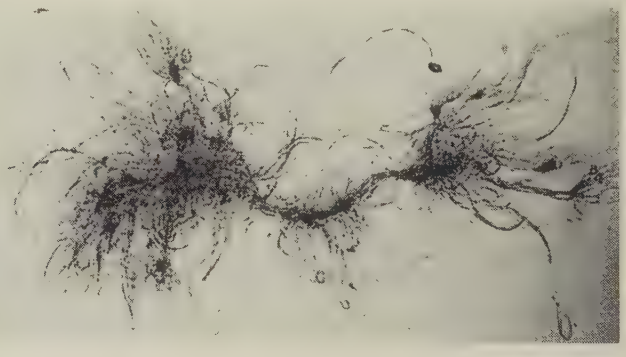

Fig. 11. Unraveled S_2 wall section (95×)

The only dimension measured on the photomicrographs taken with the metallurgical microscope was the fibrillar angle of S_1. The size of this angle varied somewhat, not only among the S_1 fragments but within in-

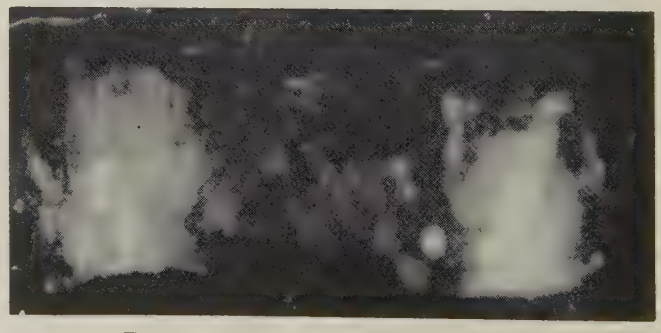

Fig. 12. Isolated S_1 fragments (375×)

dividual fragments. It is not known whether this is an intrinsic variation of S_1 or whether it was caused during the preparation of the samples. The fibrillar angle, measured in undistorted portions of 14 S_1 fragments, was 47.4° ± 15.5°.† This angle is in approximate agreement with the value of 62.7° ± 21.6° determined for *Pinus patulata* and *Pinus caribaea* by Emerton and Goldsmith (*6*).

Polarizing Microscope

Unraveled P, S_1, and S_2 material was readily identifiable between the crossed nicols of a Zeiss polarizing microscope (Fig. 12). When a first-order quartz red plate was inserted between the nicols, the fibers and unraveled material exhibited retardation colors. The retardation colors are related to the thickness of doubly-refracting materials through the equation $d = R/(n_\gamma - n_\alpha)$ (*27*); d is the thickness in μ, R, the retardation in μ, and n_γ and n_α the indices of refraction parallel and perpendicular, respectively, to the longitudinal fiber axis.

Table I. Indices of Refraction of Fibers and S_1 Layers

	n_γ	n_α	*Birefringency*
Reclassified fibers	1.584	1.526	0.058
S_2 layers	1.59	1.53	0.06

The birefringencies of the reclassified fibers and the unraveled S_2 layers were determined by measuring their two indices of refraction by the line of Becke method employing a series of Cargille liquids (*27, 28*). n_γ, n_α and the birefringencies of the fibers and unraveled S_2 layers are presented in Table I.

The fibers and the unraveled materials produced one series of colors by increasing the retardation of the quartz plate and another series by decreasing it. The retardation of the quartz plate was 540 mμ. The observed colors and the calculated thickness are presented in Table II.

The wall thicknesses calculated for the reclassified fibers agree with values for spruce reported by Meier (*13*) and by Bartunek (*14*). It is therefore concluded that the technique outlined above for measuring thicknesses of cellulosic materials is reasonably accurate.

The thickness of S_1, 0.5 μ, is considerably larger than the value, 0.11 to 0.18 μ, reported by Emerton and Goldsmith (*6*) for pine. These workers estimated the thickness of S_1 "by measuring, with a traveling microscope, the length of its shadow in the appropriate direction and multiplying this by the tangent of the angle of shadowing measured with respect to the slide." The values 0.5 μ and 0.11 to 0.18 μ may represent a real difference in the thickness of S_1 of the two species. On the other hand, the difference may be due to the magnitudes measured. In this investigation, the thickness of S_1 was measured at the centers of the fragments where the colors were most distinct. In Emerton's study, the thickness of the S_1 fragments was measured at their edges. The edges are lines of failure where S_1 may be thinner or where it may have torn in a ragged manner; i.e., only one set of fibrils may be present. In any case, Emerton's value does not hold for white spruce because

† 95% Confidence limits.

Table II. Retardation Colors and Calculated Thicknesses of Fibers and Unraveled Material

	Retardation colors greater than 540 mμ	*Retardation colors less than 540 mμ*	*Thickness, μ*
Reclassified springwood fibers	First order blue, greenish-blue	First order brownish-yellow, bright yellow	Fiber wall, 1–2
Reclassified summerwood fibers	First order blue, green; second order yellow, orange, red, and violet	Retardation of fibers as large as that of plate	Fiber wall, 2–6
P fragments	Centers first order indigo, blue; fibrils purple, violet	Centers first order brownish-yellow; fibrils reddish-orange	Centers, 1; fibrils, 0.5
S_1 fragments	First order purple, violet	First order reddish-orange	ca. 0.5
Unraveled S_2 layers	1st order purple, indigo	First order reddish-orange, brownish-yellow	0.5–1
S_2 wall sections	Centers first order blue, green; attached S_2 layers purple	Centers first order yellow; attached S_2 layers reddish-orange	Centers 2–3; attached S_2 layers, 0.5

cellulose 0.11 to 0.18 μ thick would cause a retardation of 7 to 11 μ. Retardations of this magnitude would not cause the colors observed.

The thickness of the centers of most P fragments, 1 μ, appears to be too large to be a true measure of the average thickness of P. The centers of the P fragments may be the thickenings in P observed by Bailey (*9*). On the other hand, they may have been formed by the collapse or flocculation of the sieve-forming microfibrils of P membranes during drying, or by the flocculation of several P membranes and fibrils.

CHEMICAL ANALYSES

It was pointed out previously that P and S_1 were essentially removed from the 300,000-count fibers and, therefore, these fibers are referred to hereafter as S_2 material. An attempt was made in the chemical analyses to balance the constituents of the P-S_1 and S_2 materials with those of the reclassified fibers. In many cases, the constituents which were less concentrated in the P-S_1 material than in the reclassified fibers were *most* concentrated in the S_2 material. However, this relationship did not hold quantitatively, probably because a large proportion of S_2 as well as P and S_1 had been removed from the 300,000-count fibers. Therefore, differences between the analyses of the reclassified fibers and the S_2 material may reflect in part small nonuniformities in the distribution of the constituents within S_2.

Hydrolysis

The reclassified fibers, the P-S_1 material, and the S_2 material were hydrolyzed with 72.0% sulfuric acid by the Forest Products Laboratory procedure (*29*). The residues of the hydrolyses were filtered on microgooch crucibles and weighed on a Kuhlman microbalance. The acid-insoluble residues, hereafter referred to as *F.P.L. lignin*, are tabulated in Table III.

Although there was some variance among the F.P.L. lignin values of the P-S_1 samples, all of the values were orders-of-magnitude larger than the F.P.L. lignins of the reclassified fibers and the S_2 material. It is concluded that the concentration of lignin in P and S_1 of

Table III. Chemical Analyses

	F.P.L. lignin, %	Glucose, %	Mannose, %	Xylose, %	Alpha-cellulose, %	Hemicelluloses, %	Intrinsic viscosity	D.P.
Reclassified fibers	0.5	89.9	6.5	3.1	84.0	15.5	27.0	2960
P-S_1 material	5.8	85.9	5.3	3.0	81.3	12.9	18.5	2030
S_2 material	0.4	86.1	9.6	3.9	82.6	17.0	27.0	3050

unbleached spruce sulfite fibers is 10 to 20 times as large as in S_2. This ratio is of the same magnitude as the one that Jayme and von Köppen (*3*) determined indirectly for a sulfite pulp whose total Halse lignin content was 3.6%. Therefore, their conclusion that the relatively high concentration of lignin in P and S_1 of unbleached spruce sulfite fibers reduces the amount of interfiber bonding appears to be valid.

Sugar Analysis

The sugars obtained from the acid hydrolyses were determined quantitatively by the paper chromatographic technique of Piper and Bernardin (*30*). The results of the analyses are presented in Table III; no arabinose, galactose, or uronic acids were found.

Glucose, mannose, and xylose were present in the P-S_1 material and in the reclassified fibers in essentially the same ratio, 29 : 2 : 1. Therefore, the concentrations of the sugars in P and S_1 were slightly lower than in S_2 (because of the relatively high concentration of lignin in P and S_1).

It has been proposed that the mannoglucans obtained from the cuprammonium-insoluble fraction of unbleached spruce sulfite pulps originate primarily from P and S_1 (*31*). The mannose of this fraction may represent less than 20% of the mannose available in the pulp (*32*). P and S_1 may contain up to 20% of the mannose available in unbleached spruce sulfite fibers. Therefore, it is possible that the cuprammonium-insoluble mannoglucans originated to a large extent from P and S_1, even though the overall glucose-to-mannose ratio of P and S_1 is 16 : 1.

Alpha-Cellulose and Hemicellulose Determination

The alpha-cellulose contents of the reclassified fibers, the P-S_1 material, and the S_2 material were determined by TAPPI Standard 203 m-55 (*33*). The samples were treated with 17.5% sodium hydroxide at 20°C. for 45 min. Because the P-S_1 material contained 5.8% lignin, the F.P.L. lignin content of its alpha-cellulose was determined. It was found to be 5.6%, which is equal to 4.8% of the weight of the P-S_1 material.

The filtrates from the alpha-cellulose determinations contained the hemicelluloses soluble in 17.5% sodium hydroxide, hereafter referred to as the *hemicelluloses*. The filtrate from the P-S_1 material contained a small amount of lignin calculated by difference to be equal to 1.0% of the P-S_1 material.

The results of the alpha-cellulose and hemicellulose determinations are presented in Table III.

The concentrations of the alpha-cellulose and hemicelluloses in P and S_1 were 2.7 and 2.6% *lower*, respectively, than in the reclassified fibers. These data demonstrate that the concentration of hemicelluloses is slightly *higher* in S_2 than in P and S_1. Therefore, the hemicellulose and lignin distributions across the wall of unbleached spruce sulfite fibers are not alike as hypothesized by Jayme and von Köppen (*3*). Their conclusion based on this hypothesis, that the relatively high concentration of hemicelluloses in P reduces the strength of the interfiber bonds, is in doubt.

Degree of Polymerization

The degree of polymerization (D.P.) of the reclassified fibers, the P-S_1 material, and the S_2 material was calculated from the intrinsic viscosity measurements made on the nitrated samples in ethyl acetate. The samples were nitrated with a 43 : 32 : 25 nitric acid, acetic acid, acetic anhydride mixture at 3°C. for 3 hr. to produce cellulose nitrates, assumed to contain 13.8 to 13.9% nitrogen (*34*, *35*). The intrinsic viscosities $[\eta]$, were determined in the usual manner from the specific viscosity-concentration curves (*36*). The D.P.'s were calculated from the $[\eta]$'s by Hunt's equation, $[\eta] = 2.5 \times 10^{-5} (M_w)^{1.01}$, where M_w is the molecular weight of the cellulose nitrate (*36*). The intrinsic viscosities and D.P.'s are tabulated in Table III.

The differences between the D.P.'s of the reclassified fibers and the S_2 material are so small that the D.P. of S_2 must be around 3000. It is therefore concluded that in unbleached spruce sulfite fibers, the D.P. of P and S_1 is about two-thirds the D.P. of S_2.

Jayme and von Köppen (*3*) indicated that the D.P. of P of unbleached spruce sulfite fibers is about 300. They concluded that the low D.P. of P and S_1 was partially responsible for the inferior strength properties of sulphite fibers. Because carbohydrates with a D.P.over 2000 certainly are not short-chained, Jayme and von Köppen's conclusion is in doubt.

Degree of Crystallinity

The degree of crystallinity of the reclassified fibers and the P-S_1 material was determined from diffraction patterns recorded by a North American Phillips x-ray unit. It was concluded that P and S_1 are partially crystalline, but not as crystalline as S_2. It is not known whether the difference between the crystallinity of P-S_1 and S_2 is due only to the relatively high concentration of lignin of the P-S_1 material, or also to a small difference in the degree of crystallinity of the cellulosic portions.

IMPORTANCE OF UNRAVELED P AND S_1 FRAGMENTS TO SHEET STRENGTH PROPERTIES

It was demonstrated in the following experiment that unraveled P and S_1 fragments can exert a considerable influence on sheet strength properties by acting as bonding agents. Reclassified fibers, which had been stirred 1200 counts instead of 2500 in their initial preparation, were stirred a total of 15,000 counts in the British disintegrator and then classified to remove the unraveled P and S_1 fragments. The physical properties and the sheet strength properties of the reclassified fibers, (*A*), the 15,000-count fibers, (*B*), and the classified 15,000-count fibers, (*C*), were measured.

Table IV. Physical Properties and Sheet Strength Properties of Stirred Fibers

Property	Reclassified fibers (A)	15,000-Count fibers (B)	Classified 15,000-count fibers (C)	Classified 300,000-count fibers
Filtration specific surface, cm.²/g.	10,780	38,400	17,000	70,800
Wet fiber specific volume, cc./g.	0.96	3.21	3.29	3.88
Basis weight,[a] lb./25 × 40 × 500	51.8	51.3	51.5	39.8
Apparent density,[b] lb./ream mil	12.9	16.1	15.2	16.6
Bursting strength,[c] pt./100 lb.	109	169	153	102
Tensile strength,[d] lb./in.	29.9	42.7	34.6	14.4
Tear factor,[e]	1.68	1.10	1.24	1.04
M.I.T. fold,[f]	1093	2060	1419	1733
Zero-span tensile[g] strength, lb./in.	72.0	61.5	60.7	48.8

[a–g] The handsheets were tested by the following TAPPI Standards (*33*): basis weight, T 410 m-45; apparent density, T 411 m-44; bursting strength, T 403 m-53; tensile strength, T 404 m-50; tearing strength, T 414 m-49; M.I.T. fold, T 423 m-50; zero-span tensile strength, (*41*) (IPC jaws).

The handsheets were prepared according to TAPPI Method T 205 m-58 (*33*) and tested according to the TAPPI methods listed in Table IV. The filtration specific surface and the wet fiber specific volume data were determined by the filtration resistance technique of Ingmanson (*37*).

In the analysis of the data, two assumptions were made: (1) A negligible quantity of P and S_1 fragments was lost during the formation of the handsheets of the 15,000-count fibers. (2) The 4-min. classification had a negligible effect on the properties of the 15,000-count fibers. Therefore, the differences between the properties of the 15,000-count fibers and the classified 15,000-count fibers were due primarily to the unraveled P and S_1 fragments. If X is a specific property, the fraction of the total change in X which can be attributed to the presence of unraveled P and S_1 fragments is $(X_B - X_C)/(X_B - X_A)$; the fraction of the change due to all other effects combined is $(X_C - X_A)/(X_B - X_A)$. It should be pointed out that the first of these two equations is applicable only in cases where changes in the sheet's properties can be attributed to a specific cause. The equations merely describe the extent of an observed change and do not imply cause and effect relationships.

The properties of the classified 300,000-count fibers were measured to show the effects of prolonged stirring on the properties of the reclassified fibers. Differences between the properties of these two types of fibers cannot be attributed to any specific phenomenon, but only to a general maceration of the fibers.

From the filtration specific surface and the wet fiber specific volume, it is evident that 13,800 counts of stirring created a considerable amount of hydrodynamic surface, 27,620 sq. cm. per g., and caused appreciable fiber swelling. Most of the newly created surface, 77.4% (21,400 sq. cm. per g. per 27,620 sq. cm. per g. × 100), was due to the unraveled P and S_1 fragments which comprised only 3.3% of the mass of the reclassified fibers. The unraveled P and S fragments had a hydrodynamic surface of about 650,000 sq. cm. per g. (21,400 sq. cm. per 0.033 g.). A fine, fibrous material with a specific surface of this magnitude should enhance interfiber bonding considerably.

Table V. Per Cent of Strength Property Increases Due to Unraveled P and S_1 Fragments and Due to Other Effects Combined

Property	Per cent of increase due to unraveled P and S_1 fragments	Per cent of increase due to other effects combined
Apparent density	28	72
Bursting strength	27	73
Tensile strength	63	37
Fold	66	34
Tearing strength	−24	−76

The contribution of the unraveled P and S_1 fragments, and of all other effects combined, to the strength properties developed by the reclassified fibers during the first 13,800 counts of stirring are tabulated in Table V.

The differences in the strength properties between the 15,000-count fibers and the classified 15,000-count fibers were appreciable. The decreases in the apparent density, bursting strength, tensile strength, and fold and the increase in the tearing strength, caused by the removal of the P and S_1 fragments, indicate that the unraveled P and S_1 fragments contributed to fiber-to-fiber bonding.

The reclassified fibers had exceptionally high strength properties for an essentially unbeaten, unbleached spruce sulfite pulp. The high strength properties were due primarily to the absence of cut fibers, pulping debris, and the minimal fiber damage during the pulp preparation. The data point out the excellent strength properties inherent in unbleached spruce sulfite fibers.

SWELLING OF FIBERS

The role of P and S_1 during the swelling of fibers has been studied for many years. The generally accepted mechanism of fiber swelling postulated by Wardrop and Dadswell (*31*) and by Steenberg (*38*) is as follows: Upon the application of a swelling agent, the fiber first swells uniformly, but its expansion is soon restricted by P and S_1. As the concentration of the swelling agent is increased, swelling of S_2 proceeds at the slip planes. The slip planes are cracks in P and S_1 caused by the bending or bruising of fibers. During the swelling of S_2 at the slip planes, S_1 is stretched, and it contracts perpendicularly to its fibrillar orientation. Wherever S_1 has slipped from its surface, S_2 expands still further and forms the renowned balloons. When the swelling of S_2 is at its maximum, just prior to its dissolution, S_1 is present about the fiber as a band which forms nodes at regular intervals (Fig. 13). P may remain attached to S_1, but more generally it is split from the fiber and floats away. If the concentration of the swelling agent is increased still further, S_2 dissolves. Whether or not P and S_1 also dissolve depends on their chemical composition.

On the basis of this swelling mechanism, it was hypothesized that if P and S_1 were removed from the fibers without any concurrent chemical changes, the fibers ought to swell uniformly until they dissolved. It was believed that P and S_1 were essentially removed from the 300,000-count fibers because only trace quan-

Fig. 13. Swollen reclassified fiber (190×)

tities of P and S_1 fragments were unraveled between 200,000 and 300,000 counts. Therefore, the reclassified fibers and the 300,000-count fibers which appeared to be intact were well suited to test this hypothesis. They were treated with cupriethylenediamine in a cardioid cell under the polarizing microscope according to the procedure of Isenberg and Smith (*39*).

The reclassified fibers ballooned normally. The 300,000-count fibers swelled without any apparent constrictions (Fig. 14). Before finally dissolving, the springwood fibers swelled two to four times their original diameter and the summerwood fibers three to six times. The fibers also underwent considerable lengthwise shrinkage.

The fibrils of the swollen 300,000-count fibers appeared to be oriented almost at right angles to the longitudinal fiber axis. The orientation of the S_2 fibrils apparently was altered by the swelling and contraction of the fibers.

The manner in which the reclassified fibers and the 300,000-count fibers swelled is consistent with the concept that S_1 forms the constrictions during ballooning. Therefore, the conclusion of Wardrop and Dadswell (*31*) concerning the role of S_1 during ballooning has been confirmed.

During the 1930's, it was believed that the balloons were covered with a "skin substance," presumably P, wherever S_1 had slipped from the surface of S_2. It was

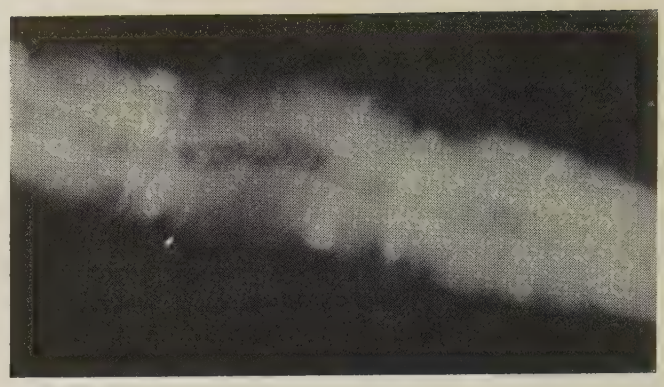

Fig. 14. Swollen 300,000-count fiber (190×)

believed that the "skin substance" prevented S_2 from dissolving until the concentration of the swelling agent was high enough to crack the skin, whereupon S_2 dissolved. Although this concept has been rejected by Wardrop and Dadswell (*31*) and by Merler and Wise (*40*) the existence or nonexistence of the "skin substance" has never been definitely established one way or the other.

If the "skin substance" does not exist, S_2 must be in direct contact with the swelling agent at the balloons. For this case, Steenberg (*38*) hypothesized that the dissolution of S_2 represents a phase change from a swollen gel to complete solution. He supported this hypothesis by demonstrating that highly swollen fibers dissolve when the concentration of the swelling agent is increased only very slightly.

If the dissolution of S_2 represents a phase change, intact fibers and fibers from which P and S_1 have been removed ought to dissolve at the same concentration. On the other hand, if a "skin substance" prevents the dissolution of the ballooned fibers, the fibers from which P and S_1 have been removed ought to dissolve at a lower concentration than the ballooning fibers. This hypothesis was tested by swelling the reclassified fibers and the 300,000-count fibers together. It was found that both dissolved *at the same concentration.* This observation confirms the conclusion of Wardrop and Dadswell (*31*) that there is "no necessity to postulate the existence of a membrane between the solvent and the cellulose gel to account for the existence of the latter as a separate phase."

CONCLUSIONS

A technique has been developed for isolating P-S_1 material and S_2 material from unbleached spruce sulphite fibers in sufficiently large quantities for chemical analyses. The isolation of the P-S_1 and the S_2 material requires only readily available equipment and it is a relatively simple and rapid technique. From the analyses of the P-S_1 and S_2 material and the original fibers, it is possible for the first time to approximate the distribution of the constituents across the wall of delignified fibers.

The distribution of the constituents across the wall of unbleached spruce sulfite fibers has been determined to be as follows: The concentration of lignin in P and S_1 is 10 to 20 times as large as in S_2 (*ca.* 5.8 vs. 0.4%). This finding substantiates a similar one obtained by Jayme and von Köppen (*3*). Therefore, their conclusion that the relatively high concentration of lignin in P and S_1 of unbleached spruce sulfite

fibers reduces the amount of interfiber bonding appears to be valid.

The carbohydrates are distributed much more uniformly across the fiber wall than postulated by Jayme and von Köppen (*3*). Contrary to their well-known assumption that the hemicellulose and lignin distributions are alike, it was found that the concentration of hemicelluloses in P and S_1 (12.9%) is slightly *lower* than in S_2 (15.5–17.0%). The distribution of the hemicelluloses is consistent with the distribution of the sugars, glucose, mannose, and xylose, which are present in an essentially constant ratio (29:2:1) across the fiber wall. The concentration of alpha-cellulose in P and S_1 (81.3%) is slightly *lower* than in S_2 (82.6–84.0%). The D.P. of P and S_1, 2030, is about two-thirds that of S_2. This finding demonstrates that P and S_1 are not composed of short carbohydrate chains with an average D.P. of 300 as postulated by Jayme and von Köppen (*3*). P and S_1 are partially crystalline, but not as much as S_2. It was not determined whether this difference is due only to the relatively high concentration of lignin in P and S_1, or also due to a real difference in the crystallinity of the carbohydrates in P and S_1 and in S_2.

It is concluded that the strength of the interfiber bonds between unbleached spruce sulfite fibers is not reduced appreciably by a high concentration of hemicelluloses and low D.P. cellulose in P and S_1 as postulated by Jayme and von Köppen (*3*).

The P and S_1 fragments unraveled from the reclassified fibers in the British disintegrator have a huge hydrodynamic surface, 650,000 sq. cm. per g. A fine, fibrous material with a specific surface of this magnitude should improve sheet strength properties considerably. Under the conditions used in this investigation, it was found that the unraveled P and S_1 fragments were responsible for over 25% of the increase in bursting strength and for over 60% of the increase in the fold and tensile strength. Therefore, it is believed that the importance of P and S_1 to the papermaker has been underestimated.

Two hypotheses on the mechanism of swelling were substantiated: (1) The theory of Wardrop and Dadswell (*31*) that S_1 is responsible for the constrictions formed during ballooning was corroborated. (2) The hypothesis of Steenberg (*38*) that the dissolution of ballooned fibers represents a phase change was strengthened. Therefore, it is concluded in agreement with these investigators that the "skin substance" concept is unnecessary to explain ballooning.

The S_2 wall unraveled in two distinctly different ways. A hypothesis is presented which relates these types of fibrillation to fiber structure.

Two controversial morphological characteristics of fibers were studied. The conclusion of Emerton and Goldsmith (*6*) that S_1 contains two sets of fibrils with a fibrillar angle of about 60° was confirmed for spruce. The conclusion of Wardrop and Dadswell (*20*) that S_2 and the layer bordering the lumen have the same fibrillar orientation was confirmed.

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Oxidation of Some Simple Organic Molecules with Aqueous Chlorine Dioxide Solutions

I. Kinetics

ROGER A. SOMSEN

Chlorine dioxide oxidations of 2,3-butanediol, acetoin, diacetyl, ethanol, acetaldehyde, and *n*-butyraldehyde were studied in dilute aqueous solutions buffered at pH 1 and 7. Chlorine dioxide consumption was followed by iodometric determination of total active chlorine concentration. The oxidations at both pH 1 and 7 were of apparent zero order and the hydroxyl compounds at each pH were found to be more stable to chlorine dioxide attack than carbonyl compounds.

Chlorine dioxide has become an increasingly important bleaching agent over the past decade. Consequently, in order that the most intelligent use can be made of its bleaching properties, it is desirable that a complete understanding of its chemical reactions be obtained. Previous studies of its reactions with cellulose and carbohydrate material (*2–6*) were concerned with the effect of chlorine dioxide upon the organic material. The reaction kinetics of the chlorine dioxide oxidation of an organic material have not been studied.

The organic compounds chosen for oxidation in this kinetics study were simple compounds each containing one of the functional groupings proposed to be present in cellulose at different degrees of oxidation (*6*). These functional groupings are illustrated in Fig. 1 as they would be present in both the hypothetical oxidized celluloses and the simple compounds chosen for study. Since these compounds were chosen on the basis of their cellulosic functional groupings, this kinetics study provides a foundation for understanding the more complex oxidation of cellulose by chlorine dioxide.

EXPERIMENTAL

Material

2,3-Butanediol (EK P3400) was purified by the method of Leslie and Castagne (*7*). Acetoin (EK P3788) and diacetyl (EK 1591) were purified by the method of Westerfeld (*8*). Acetaldehyde (EK 468) was purified by fractional distillation under nitrogen. *n*-Butyraldehyde (EK 440) was purified by drying over Drierite and fractionally distilling under nitrogen. Absolute ethanol was purified by the method of McComb and McCready (*9*).

Aqueous chlorine dioxide solutions were prepared by passing a chlorine gas-air mixture continuously through two sodium chlorite columns in an apparatus similar to that described by Hutchinson and Derby (*10*). Unreacted chlorine was removed by washing the gas stream with a saturated barium hydroxide solution (*11*). The chlorine dioxide was then dissolved in triple-distilled water adjusted to about pH 2 with nitric acid to prevent chlorine dioxide decomposition.

Oxidations

Reaction mixtures were prepared in volumetric flasks immersed in a bath at oxidation temperature. Buffer solution was added to the flasks first—25

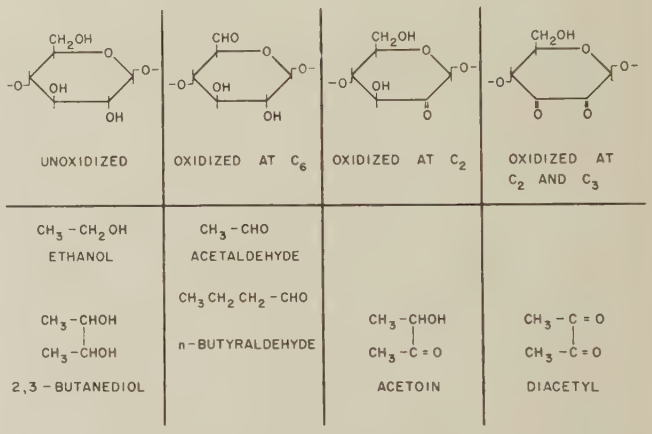

Fig. 1. Comparison of structures of hypothetical oxidized celluloses and analogous simple compounds

ml. of nitric acid-potassium nitrate buffer (105 g. KNO_3 and 51 ml. concentrated HNO_3 dissolved in 978 ml. triple-distilled water) was added for each 100 ml. of total reaction mixture at pH 1 and 45 ml. of monodipotassium phosphate buffer (400 g. K_2HPO_4 and 50 ml. 85% H_3PO_4 dissolved in 1800 ml. triple-distilled water) was added for each 100 ml. of total reaction mixture at pH 7. A solution of the organic material was prepared by weight in triple-distilled water and the volume of this solution required to give the desired organic concentration in the reaction mixture was added next. Correct volume of chlorine dioxide solution to give about a 0.01 *M* solution was transferred quantitatively to the flask with the device shown in Fig. 2. The flask contents were then diluted to volume with triple-distilled water at the oxidation temperature and mixed thoroughly. The completed reaction mixture was then transferred to 100-ml. hypodermic syringes covered with aluminum foil by applying slight positive pressure to the volumetric flask and a delivery tube was then attached to the syringe.

Samples for determination of chlorine dioxide concentration were weighed into a potassium iodide-sulfuric acid-phosphate buffer solution and titrated

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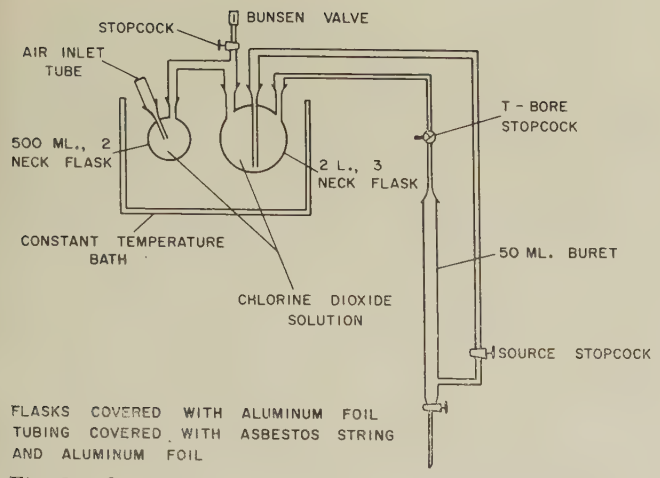

Fig. 2. Quantitative transfer device for aqueous chlorine dioxide solutions

with 0.01*N* sodium thiosulfate to determine total active chlorine concentration by the acid titration method of Giertz (*12*). Sample weight was converted to volume with reaction mixture density.

The effect of buffer concentration upon the rate of reaction was shown by adding only 80% of the normal amount of buffer solution at pH 1 and 67% at pH 7. Ionic strength effects at pH 7 were eliminated by adding 40 ml. of 0.775 molal sodium sulfate solution to the low buffer concentration mixture. Surface area effects

Table I. Reaction Conditions at pH 7

Compound	*Initial concn. ClO_2, M*	*Initial concn. organic, M*	*Temperature, °C.*
Ethanol	0.0065	0.0100	80
2,3-Butanediol	0.0069	0.0100	80
Acetoin	0.0100	0.0100	30, 40, 50
Diacetyl	0.0100	0.0100	10
Acetaldehyde	0.0100	0.0200	10, 20

upon reaction rate during acetoin oxidations at pH 1 were shown by adding sufficient glass fibers to the reaction mixture to double the available surface area.

RESULTS AND DISCUSSION

The experimental conditions under which the reactions at pH 7 were studied are listed in Table I. The reactions with the carbonyl compounds were rapid at 10°C., whereas no reaction was found for hydroxyl compounds even at 80°C.

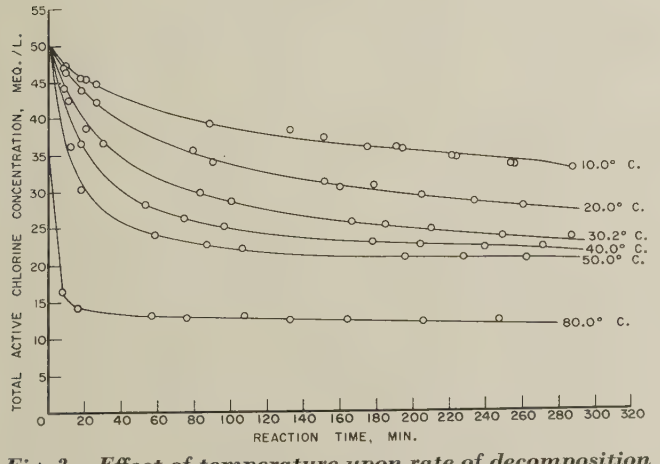

Fig. 3. Effect of temperature upon rate of decomposition of chlorine dioxide solutions buffered at pH 7 with phosphate

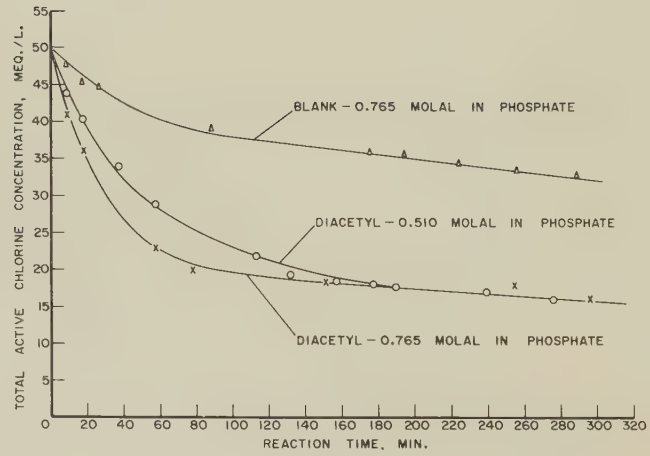
TOTAL ACTIVE CHLORINE CONCENTRATION, MEQ./L.
REACTION TIME, MIN.
BLANK – 0.765 MOLAL IN PHOSPHATE
DIACETYL – 0.510 MOLAL IN PHOSPHATE
DIACETYL – 0.765 MOLAL IN PHOSPHATE

Fig. 4. Effect of phosphate buffer (pH 7) concentration upon rate of reaction with diacetyl at 10°C.

Chlorine dioxide solutions buffered at pH 7 were found to be unstable. The effect of temperature upon this decomposition is shown in Fig. 3. Even at 10°C., this decomposition caused a marked decrease in chlorine dioxide concentration. Taube and Dodgen (*13*) and Brown (*14*), respectively, have proposed the following two equations for chlorine dioxide solution decomposition:

$$ClO_2 + H_2O \leftrightharpoons HClO_2 + HClO_3$$

$$6ClO_2 + 3H_2O \rightarrow 5HClO_3 + HCl$$

The oxidation of diacetyl at pH 7 is illustrated in Fig. 4. Determination of the consumed chlorine dioxide for kinetic analysis by the difference in oxidant concentration in the blank and organic oxidations is not theoretically sound because of the more rapid rate of formation of inorganic reaction products and of the lower chlorine dioxide concentration in the organic reaction mixture. Both of these effects result in a slower decomposition rate in the organic oxidation and, therefore, overcompensation by the blank. Since the analytical methods for the individual determination of chlorite, chlorine dioxide, and chlorate were too lengthy and inaccurate for kinetics work, this difference technique was applied to three oxidations. The results are illustrated in Fig. 5. The reaction rates ap-

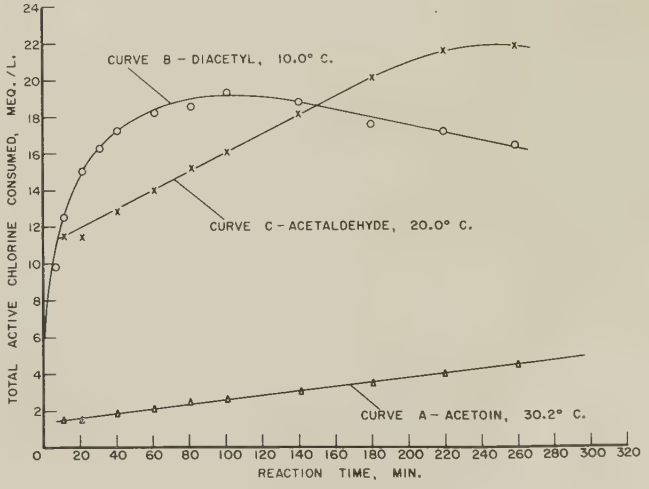
TOTAL ACTIVE CHLORINE CONSUMED, MEQ./L.
REACTION TIME, MIN.
CURVE B – DIACETYL, 10.0° C.
CURVE C – ACETALDEHYDE, 20.0° C.
CURVE A – ACETOIN, 30.2° C.

Fig. 5. Total active chlorine consumed at pH 7 as determined by the difference technique

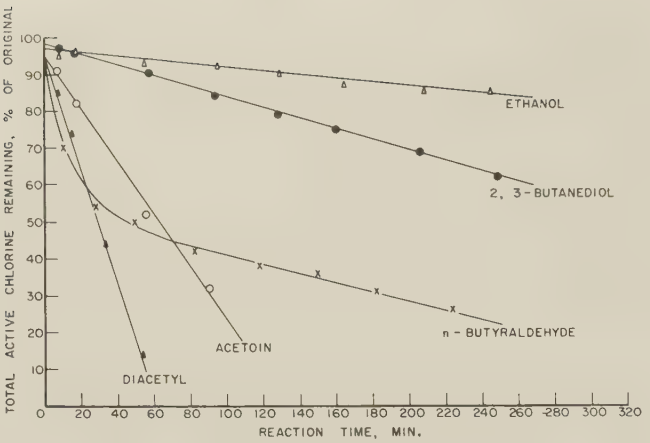

Fig. 6. Reaction curves at pH 1 and 80°C.

pear to be zero order over an extended period of the oxidation of acetoin and acetaldehyde when the rate of consumption is not too rapid and the concentration difference is not too large.

The effect of buffer concentration upon reaction rate is also shown in Fig. 4. This effect was not the result of changes in ionic strength and, consequently, it must be due to buffer catalysis which is not uncommon during halogen oxidations.

Table II. Reaction Conditions at pH 1

Compound	*Initial concn. ClO_2, M*	*Initial concn. organic, M*	*Temperature, °C.*
Ethanol	0.008	0.0100	70, 80
2,3-Butanediol	0.008	0.0100	70, 80
Acetoin	0.008	0.0100	60, 80
Diacetyl	0.008	0.0100	60,80
n-Butyraldehyde	0.010	0.0100	40, 50, 60, 80

A summary of the experimental conditions under which reactions at pH 1 were studied is given in Table II. Comparison with Table I shows that higher temperatures are required for reactions to occur with carbonyl compounds at pH 1 than at pH 7. While the hydroxyl compounds were stable at 80°C. at pH 7, reaction did occur at 70°C. at pH 1. Therefore, hydroxyl attack occurs more readily at pH 1 while carbonyl attack is easier at pH 7.

Table III. Reaction Coefficients at pH 1

Compound	*Temperature, °C.*	*$k^a \times 10^5$*	*E_a[b]*	*Temperature coefficient*
Ethanol	80	1.6	21	2.5
	70	0.65		
2,3-Butanediol	80	5.7	19	2.2
	70	2.6		
Acetoin	80	21	18	2.1
	60	4.9		
Diacetyl	80	56	21	2.9
	60	9.8		
n-Butyraldehyde	80[c]	6.0	14	1.7
	60[c]	1.8		
	50[d]	6.0		
	40[d]	4.3	6.8	1.4

[a] (Equivalents total active chlorine)/(liter) (minute).
[b] Kilogram-calories/mole.
[c] Based on final rate.
[d] Based on initial rate.

The stability of the various functional groups to chlorine dioxide attack at pH 1 can be ranked in the following order from Fig. 6: primary alcohol> α-glycol > α-hydroxyketone > α-diketone > aldehyde. This same stability ranking can be surmised for the oxidations at pH 7. When *n*-butyraldehyde was oxidized at lower temperatures, the curve in Fig. 6 was shown to be made up of two successive zero order reactions. Only one reaction could be measured for each of the other compounds, however.

Since blank chlorine dioxide solutions did not decompose at pH 1, the rate constants for the apparent zero order oxidations of each compound could be determined. Reaction rate constants, activation energies, and temperature coefficients for each oxidation are listed in Table III.

In contrast to the reaction rates at pH 7, reaction rates at pH 1 were not affected by buffer concentration. The addition of surface area to a pH 1 reaction mixture also had no effect upon the reaction rate.

In conclusion, the following results were observed during the kinetics studies of the chlorine dioxide oxidations of six compounds each containing one of the possible functional groupings present in cellulose:

1. All of the oxidations at pH 1 were of apparent zero order, and it appears that the same is true for oxidations at pH 7.
2. Hydroxyl groups were found to be more stable to attack than carbonyl groups at both pH 1 and 7.
3. Higher temperatures were required for the oxidation of carbonyl compounds at pH 1 than at pH 7 while the reverse is true for hydroxyl compounds.
4. Two successive apparent zero order reactions were detected during the oxidation of *n*-butyraldehyde at pH 1. Only one reaction was detected for each of the other compounds.
5. Aqueous chlorine dioxide solutions decomposed rapidly when buffered at pH 7. There was no decomposition when the solution was buffered at pH 1.

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A portion of a thesis submitted in partial fulfillment of the requirements of The Institute of Paper Chemistry for the degree of Doctor of Philosophy from Lawrence College, Appleton, Wis., June, 1958. This work was carried out under the direction of B. L. Browning.

Oxidation of Some Simple Organic Molecules with Aqueous Chlorine Dioxide Solutions

II. Reaction Products

ROGER A. SOMSEN

Diacetyl and 2,3-butanediol were oxidized with dilute aqueous chlorine dioxide solutions buffered at pH 1. Isolation of acetic acid and carbon dioxide as reaction products from each of these compounds showed that there was carbon-carbon cleavage during the chlorine dioxide oxidations resulting in the formation of carboxyl groups and carbon dioxide. The experimental results have been related to the chlorine dioxide oxidation of cellulose.

CHLORINE dioxide was originally thought to be specific in its bleaching reactions, attacking only the noncarbohydrate material present in pulp. This concept was based upon the work of Schmidt and Graumann (*1*) who reported that cellulose, oxidized cellulose, sugars, and other similar compounds were not attacked appreciably by chlorine dioxide. Staudinger and co-workers (*2, 3*), however, showed that chlorine dioxide lowered the degree of polymerization (D.P.) of cellulose, while Jeanes and Isbell (*4*) found that aldose sugars were attacked slowly.

The effect of chlorine dioxide on cellulose has been best exemplified by the work of Lapèze and Dardelet (*5*). With the application of large amounts of chlorine dioxide at 70°C., they were able to show marked decreases in D.P. and alpha-cellulose content and marked increases in copper number and carboxyl content over the pH range 2 to 7. Samuelson and co-workers (*6, 7*), however, have shown that normal amounts of chlorine dioxide caused no appreciable change in either the D.P. or hot alkali solubility of a normally bleached sulfite pulp. When the pulp had been overbleached with chlorine to produce carbonyl groups, however, chlorine dioxide treatment caused large increases in the carboxyl content and decreases in the carbonyl content of the pulp. Therefore, it is apparent that while the hydroxyl groups in cellulose are quite resistant to attack by chlorine dioxide, any carbonyl groups present are quite susceptible to attack. These analytical methods used with cellulose, however, show only that cellulose was attacked with no indication of *how* or *where* this attack took place.

The path of an oxidation can be followed more completely when simple molecules, each containing one of the possible functional groups present in cellulose (*8*), are oxidized. Ethanol, representing the primary hydroxyl group on C_6, was oxidized with chlorine dioxide by Bhaduri (*9*). Acetic acid was the primary reaction product but the experimental conditions were too severe to allow any correlations with cellulose oxidations by chlorine dioxide. Somsen (*10*) studied the effect of cellulose functional grouping (primary alcohol, α-glycol, α-hydroxyketone, α-diketone, and aldehyde), temperature, and pH upon the rate of consumption of chlorine dioxide during the oxidations of ethanol, 2,3-butanediol, acetoin, diacetyl, acetaldehyde, and *n*-butyraldehyde. Each of the oxidations appeared to be zero order at both pH 1 and 7 and hydroxyl groups were more stable to attack than carbonyl groups at both pH 1 and 7.

This work, based on the reactions of chlorine dioxide with the possible cellulose functional groups when present in simple molecules, was continued with the isolation of reaction products from the oxidations of diacetyl and 2,3-butanediol at pH 1. Knowledge of the reaction products from these oxidations characterizes the oxidizing properties of chlorine dioxide and thus provides a foundation for understanding its reactions with cellulose.

METHODS AND MATERIALS

Diacetyl (EK 1591) was purified by the method of Westerfeld (*11*) and 2,3-butanediol (EK P3400) was purified by the method of Leslie and Castagne (*12*). Reaction mixtures were prepared in 1-l. volumetric flasks by the method of Somsen (*10*).

Nongaseous reaction products were separated by the scheme shown in Table I. Three fractions—concentrated Freon-TF extract, steam distillation residue, and steam distilled, extracted reaction mixture—were analyzed for reaction products. Since gas chromatography is an excellent method for the determination of volatile compounds, it was used to analyze the reaction mixture. Gas chromatography columns, however, are not able to handle large quantities of water. Consequently, each 100 ml. of reaction mixture was extracted with 200 ml. of redistilled Freon-TF solvent in a Schmall, continuous liquid-liquid extractor (*13*). The Freon-TF solution was concentrated by fractional distillation at 58°C. The concentrated extract was then analyzed on a $12^2/_3$ ft. long by $^1/_2$-in. i.d. glass column packed with 29% (w/w) Dow Corning Silicone 710 Fluid on 30–60 mesh, crushed, C-22 diatomaceous earth firebrick. The column was operated at 70 and 100°C. at a helium flow rate of 200 ml. per min. (S. T. P.). Fractions were removed from the helium stream by freezing and identified by their infrared spectra. After identification, the amount of material in each fraction was determined from Beer's law curves.

All three of the fractions were analyzed for nonvola-

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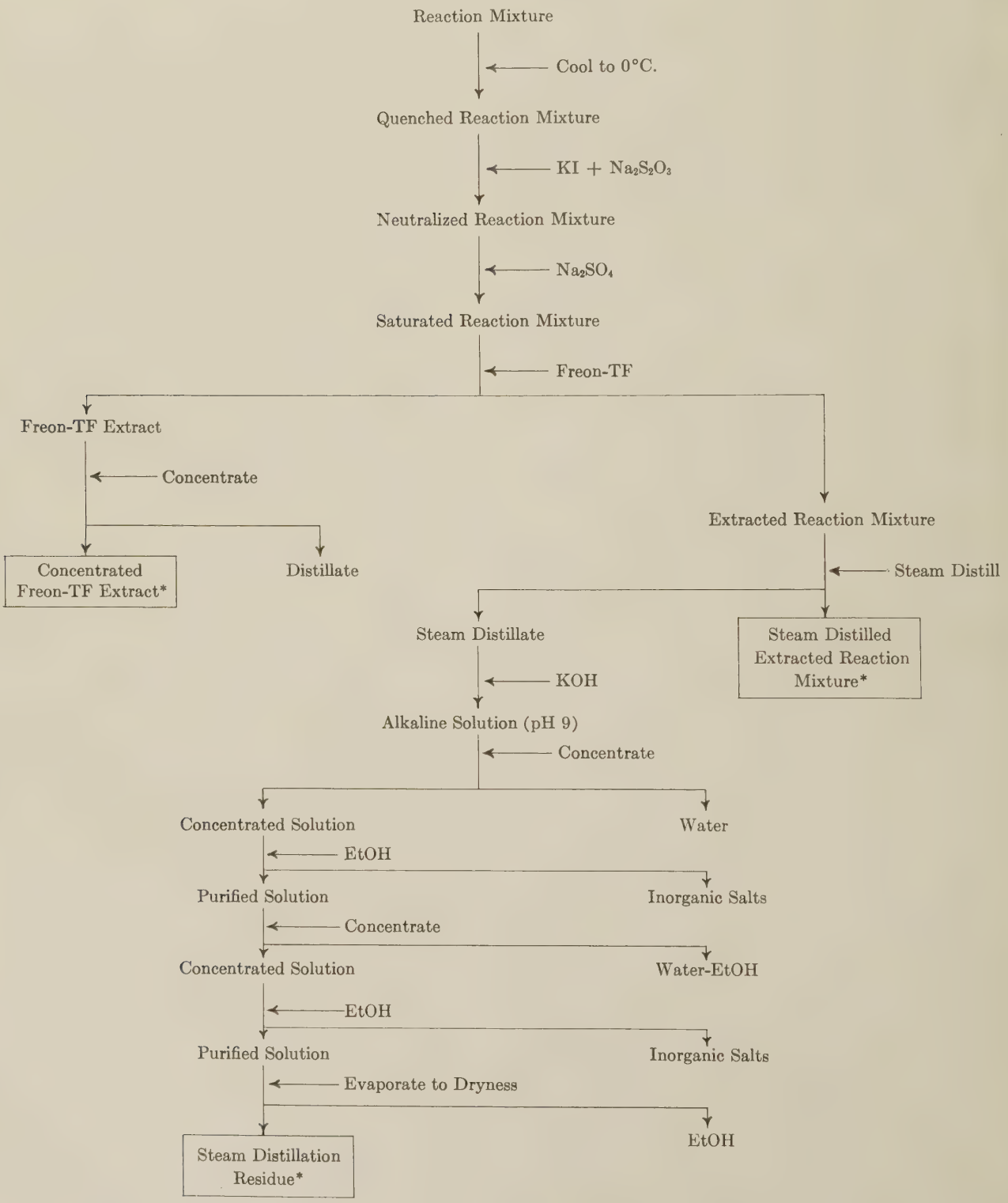
tile components by means of paper chromatography. Sheets developed in ethanol: ammonia (100:1) were sprayed with formaldehyde and methyl orange to show the presence of acids. Sheets developed in ethyl acetate:acetic acid:formic acid:water (18:3:1:4) were sprayed with 2,4-dinitrophenylhydrazine and potassium hydroxide to show the presence of carbonyl material.

The steam distillation residue was also analyzed by means of the infrared spectrum of a potassium bromide pellet. The amount of this fraction was determined from its weight.

Carbon dioxide liberated during the oxidation was

Table I. Separation of Organic Reaction Products



* Fractions analyzed.

Table II. Reaction Product Analysis for Diacetyl[a] and 2,3-Butanediol[b] Oxidations

Fraction	Diacetyl oxidation results: Gas chromatography	Diacetyl oxidation results: Paper chromatography	2,3-Butanediol oxidation results: Gas chromatography	2,3-Butanediol oxidation results: Paper chromatography
Concentrated Freon-TF extract	Unreacted diacetyl present	No acid spots No carbonyl spots	Very small amount carbonyl material present	No acid spots No carbonyl spots
Steam distillation residue	.....	KOAc[c] present No carbonyl spots	.....	KOAc[c] present No carbonyl spots
Steam distilled extracted reaction mixture	.....	No acid spots No carbonyl spots	.....	No acid spots No carbonyl spots

[a] Oxidation carried out at pH 1 and 60°C. for 8 hr.
[b] Oxidation carried out at pH 1 and 80°C. for 19 hr.
[c] Potassium acetate.

determined by bubbling nitrogen through both a completed blank (containing no organic material) and a completed organic oxidation mixture. The nitrogen stream was washed twice with acidic potassium iodide to remove chlorine dioxide and once with 2,4-dinitrophenylhydrazine to remove carbonyl material before drying with Drierite and magnesium perchlorate. The carbon dioxide was then absorbed on Ascarite and determined by weight.

DISCUSSION OF RESULTS

The results from the chromatographic analysis of the three final fractions from the oxidations of diacetyl and 2,3-butanediol at pH 1 are listed in Table II. Acetic acid, isolated as potassium acetate, is the only nongaseous reaction product that was found in large enough quantities to be identified by infrared spectra and paper chromatography in each oxidation. The formation of acetic acid indicates that these functional groups are oxidized with a cleavage of carbon-carbon bonds. This cleavage resulted in the formation of acetic acid from both α-diketone and α-glycol groupings.

Gas chromatograph analysis of the concentrated Freon-TF extract from the oxidation of 2,3-butanediol showed the presence of a very small amount of material with the retention volume of diacetyl. Infrared spectrum analysis of this material was difficult because the extremely small amount present produced only small absorption peaks. The spectrum, however, did show the three major absorption bands of diacetyl (5.81, 7.38, and 8.99 μ). The carbonyl band at 5.81 μ, however, appeared as a shoulder on a stronger band at 5.77 μ. Absorption at this wavelength may be attributed to α-halogen substituted ketones, α-halogen substituted acids, or saturated aliphatic aldehydes. The remaining bands in the spectrum were not of sufficient strength to allow correlations of spectra with structure. The 2,4-dinitrophenylhydrazine derivative(s) of this material was prepared and, without purification, was found to char at 288 to 292°C. Diacetyl bis(2,4-dinitrophenylhydrazone) chars at 315°C. Although no irrevocable proof for the presence of diacetyl has been established, both the infrared spectrum of the fraction and the decomposition point of its derivative indicate that it is present in this trace material.

The possible presence of diacetyl in this oxidation mixture indicates that the mechanism of the 2,3-butanediol oxidation may involve the conversion of at least part of the α-glycol groupings to α-diketone groupings before the molecules are split into carboxylic acid molecules. The concentration of diacetyl could never become very large, however, because of its rapid oxidation by chlorine dioxide to acetic acid and carbon dioxide.

The material balance summaries for these oxidations are presented in Table III. These data show that appreciable amounts of carbon dioxide have also been isolated as a reaction product from both oxidations, showing that the molecules were oxidized beyond the carboxylic acid stage. The yield values reported in these tables, however, are probably low because there was undoubtedly some loss of unreacted diacetyl during the concentration of the Freon-TF extract in Run 68 and no unreacted 2,3-butanediol was recovered in Run 69; in addition, the steam distillation residue yield was not quantitative.

Table III. Material Balance Summary for Oxidation of Diacetyl[a] and 2,3-Butanediol[b]

	Run number: 28	71	29	70
	Diacetyl oxidation		2,3-Butanediol oxidation	
Initial concentration				
ClO_2	0.0103 *M*	0.0139 *M*	0.0119 *M*	0.0121 *M*
Starting organic material	0.0100 *M*	0.0100 *M*	0.0101 *M*	0.0103 *M*
Total volume, ml.	1000	1000	1000	1000
Reaction time, hr.	8	8	19	19
ClO_2 consumed, millimole	9.6	...	10.3	...
Compounds determined, millimole				
Acetic acid	6.3	...	4.5	...
CO_2	...	2.4	...	0.8
Unreacted starting organic material	1.0	...	...	...
Compound yields[c]				
Acetic acid	32	...	22	...
CO_2	...	6	...	2
Unreacted starting organic material	10	...	...[d]	...
Total yield, %	48[e]		24[e]	

[a] Oxidations carried out at pH 1 and 60°C.
[b] Oxidations carried out at pH 1 and 80°C.
[c] Molar percentage of initial starting organic material.
[d] None found but test sensitivity low.
[e] Total yield could not be determined from any single run.

SUMMARY AND SIGNIFICANCE OF WORK

The results from the kinetic (*10*) and reaction product studies on the oxidations of these simple compounds are combined and related to possible chlorine dioxide oxidation of cellulose as follows:

1. Carbonyl groups were found to react more readily with chlorine dioxide than hydroxyl groups at both pH 1 and 7. This observation correlates directly with the slight cellulose degradation produced by chlorine dioxide on a normally bleached pulp and the marked degradation of an overbleached pulp.

2. The carbonyl compounds were found to react rapidly with chlorine dioxide at pH 7 while hydroxyl compounds did not react. This result would mean that during bleaches near the neutral point, the reactions between chlorine dioxide and cellulose should be limited to those points in the anhydroglucose chains which had already been oxidized to carbonyl groups in the previous bleaching steps. Therefore, if the previous bleaching operations have not damaged the pulp, there should be little cellulose attack by chlorine dioxide near the neutral point, resulting in a high quality, superbleached pulp.

3. Hydroxyl groups were found to be stable to chlorine dioxide attack at pH 7 but were oxidized slowly at pH 1. Consequently, more oxidative attack on the hydroxyl groups in cellulose could be expected as the bleach liquor pH decreases.

4. Acetic acid and carbon dioxide were isolated as reaction products from the oxidations of diacetyl and 2,3-butanediol. This cleavage of carbon-carbon bonds during cellulose oxidations would result in the formation of carboxyl groups at the C_2 and C_3 positions in the anhydroglucose units.

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A portion of a thesis submitted in partial fulfillment of the requirements of The Institute of Paper Chemistry for the Degree of Doctor of Philosophy from Lawrence College, Appleton, Wis., June, 1958. This work was carried out under the direction of B. L. Browning.

Di(Phenylmercuric)-Ammonium Propionate—A New Slime Control Agent

S. J. LEDERER and WILLIAM J. DELANEY

Several hundred new organo-mercurials were investigated as potential slime control agents. The di(phenylmercuric)-ammonium salts were found to be highly effective toxicants and one of this series, di(phenylmercuric)-ammonium propionate, proved to be one of the most powerful antimicrobial agents yet reported when tested against the common slime forming agents. The propionate was evaluated in two paper mills and was found to be a considerably more effective slimicide than the phenylmercurials used. The increased slimicidal efficiency is attributed to the stable quaternary ammonium complex form of the compound which minimized deactivation under conditions where other types of organo-mercurials are converted to less active forms.

The problem of slime control in the paper and pulp industries has been widely investigated and discussed particularly during the last 15 years. Hundreds of potential slime control agents have been prepared and evaluated in many laboratories and promising products have been tested under field conditions in mills. Despite all of this research with many types of compounds varying from antibiotics to organometallics, phenylmercurials have remained the most widely used slimicides (*1*).

As the result of an extensive research program in our laboratories, a series of organo-mercurials were prepared which proved to be extraordinarily effective antimicrobials. These compounds, the di(phenylmercuric) -ammonium salts, differ from any of the previously investigated compounds in being quaternary ammonium complexed organo-mercurials in which the complex is extremely stable and remains intact.

The remarkable strength of this complex can best be demonstrated by its ability to form salts with all types of active hydrogen compounds ranging from the strong inorganic acids such as hydrochloric and nitric to the weakly acidic enol, ethyl acetoacetate. Tables I to VII list representative compounds from several of the groups of salts prepared and screened in these laboratories where D represents the di(phenylmeric)-ammonium ion.

This is not the first ammonium complex of a phenylmercury salt reported to have antimicrobial properties. Previous investigators (*2, 3, 4*) have used ammonium

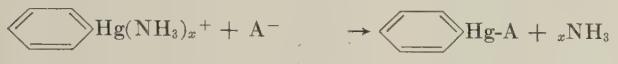
S. J. Lederer, Technical Director, and William J. Delaney, Senior Microbiologist, Metalsalts Corp., Hawthorne, N. J.

Table I. Inorganic Salts

Salt	*Structure*	*M.P., °C.*
Chloride	D[a]-Cl	185–187
Bromide	D-Br	188–190
Iodide	D-I	198–199
Nitrate	D-NO_3	230–235

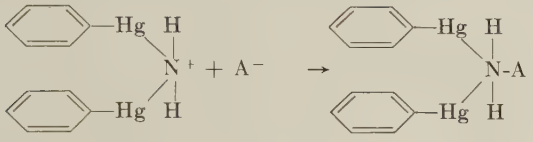
[a] D = di(phenylmercuric)-ammonium ion.

hydroxide and ammonium salts to solubilize various phenylmercurials. In all cases, however, these solubilized products reacted in exactly the same manner as phenylmercuric acetate, yielding all of the characteristic products obtained with the pure compound.



A^- = Cl^-, Br^-, RS^-, etc.
x = 0–2

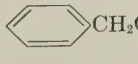
In contrast, the mercury-nitrogen linkage in the di-(phenylmercuric)-ammonium salts is so stable that it has been possible to synthesize hundreds of di-(phenylmercuric)-ammonium compounds which retain the structure in solution and in the solid form.



The importance of this stable complex in producing compounds biologically more active than the phenylmercurials can be seen from a brief consideration of the mechanism of biological action of the mercurials and the effect of interfering substances on this mechanism.

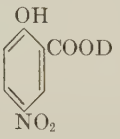
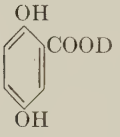
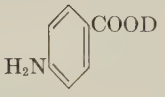
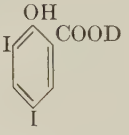
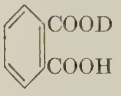
Inhibition of the growth of microorganisms has long been attributed to the reaction of mercurials with sulfur-containing substances such as cysteine present in the organism (*5*, *6*, *7*). The mercurial forms a very stable mercury-sulfur linkage which results in the death of the organism by interference with the life processes of the cell, enzymatic or otherwise. This killing effect can be moderated or prevented by the introduction of substances which will react preferentially with the mercurial. The widespread use of B.A.L. (2, 3 di-thioglycerin) as an antidote for heavy-metal poisoning (*8*) is based on the fact that this compound forms a stronger bond with the metal than the sulfur compounds present in the host.

Table II. Aliphatic Carboxylic Acid Salts

Salt	*Structure*	*M.P., °C.*
Formic	HCOOD[a]	144–145
Acetic	CH_3COOD	177–179
Acrylic	CH_2=CHCOOD	153–156
Propionic	CH_3CH_2COOD	179–181
Butyric	$CH_3(CH_2)_2COOD$	138–140
Methacrylic	CH_2=$CH(CH_3)COOD$	155–160
Isovaleric	$CH_3(CH_2)_3COOD$	115–118
2-Ethylhexanoic	$CH_3CH(C_2H_5)(CH_2)_3$-COOD	105–110
Lactic	$CH_3COCOOD$	160–165
Glycolic	$CH_3CHOHCOOD$	193–195
Lauric	$CH_3(CH_2)_{10}COOD$	95–100
Myristic	$CH_3(CH_2)_{12}COOD$	90
Undecylenic	$CH_3(CH_2)_9COOD$	90–93
Oleic	$CH_3(CH_2)_7CH$=CH-$(CH_2)_7COOD$	50
Stearic	$CH_3(CH_2)_{16}COOD$	60–65
Phenyl acetic		175–180

[a] D = di(phenylmercuric)-ammonium ion.

Table III. Aromatic Carboxylic Acid Salts

Salt	*Structure*	*M.P., °C.*
Benzoic		153–154
5-Nitrosalicylic		128–130
2,5-Dihydroxybenzoic		159–164
p-Aminobenzoic		165–175
3,5-Di-iodosalicylic		159–164
o-Phthalic		220–224

The water system used in the manufacture of pulp and paper contains a great variety of substances, apart from the pulp itself, which will deactivate phenylmercurials. Chlorides, sulfides, mercaptans, casein, and vegetable gums are a few examples of materials which can result in the conversion of the mercurial to a less desirable form. Organo-mercurials such as phenylmercuric acetate react with sulfur compounds to form the extremely stable mercury-sulfur linkage which partially deactivates the mercurial, thus protecting the slime producing organisms in much the same way the B.A.L. protects against mercury poisoning. The di-(phenylmercuric)-ammonium salts cannot form a mercury-sulfur linkage but do form a much weaker nitrogen-sulfur bond and therefore will remain in an active form. This is particularly important since it insures greater utilization of slimicide in the closed system used in most mills today.

Table IV. Miscellaneous Heterocyclic Carboxylic Acids

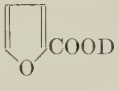
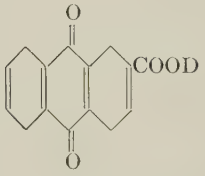
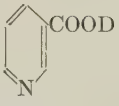
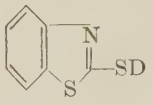
Salt	*Structure*	*M.P., °C.*
Furoic		90–95
Carboxyanthroquinone		190–193
Nicotinic		140–145

Table V. Thiols

Salt	*Structure*	*M.P., °C.*
Mercaptobenzothiazole		135–140
Isooctylthioglycolate	$C_8H_{17}OOCCH_2SD$	55–60
p-Cl-thiophenol		138–140

In the presence of chloride ions phenylmercurials presently in use as slime control agents give phenylmercuric chloride which melts at 250°C. and is only 0.001% soluble in water. Di(phenylmercuric)-ammonium salt when treated in the same manner with chloride ions retain the more active complex form and yield di-(phenylmercuric)-ammonium chloride, m.p. 183 to 185°C., which is 0.2% soluble in water. The advantage of the di(phenylmercuric)-ammonium salt is readily apparent since it results in the formation of a product which is more effective as a slimicide and 2,000 times more soluble than that obtained with phenylmercuric and chloride ions.

Table VI. Phenols

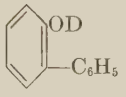
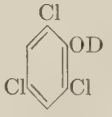
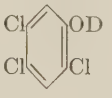
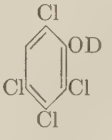
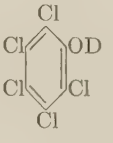
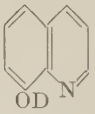
Salt	*Structure*	*M.P., °C.*
Phenol		104–107
o-Phenylphenol		118–123
o-Nitrophenol		170–175
o-Chlorophenol		135–140
2,4,6-Trichlorphenol		183–191
2,4,5-Trichlorphenol		>220
2,3,4,6-Tetrachlorphenol		190–194
Pentachlorphenol		210–212
8-Hydroxyquinoline		120–126

Table VII. Miscellaneous Compounds

Salt	*Structure*	*M.P., °C.*
Sulfamic acid	NH_2SO_3D	>260
p-Toluene sulfonic acid		178–183
Ethyl acetoacetate	$CH_3C(OD)=CHCOOC_2H_5$	205–208
Benzene sulfonamide		195–200
Barbituric acid	$C_4H_3N_2O_3D$	>250

The remarkable solubility advantage in water of the di(phenylmercuric)-ammonium salts over the phenylmercury salts was found to hold for all compounds studied. In no case was the di(phenylmercuric)-ammonium compound less soluble and in several instances the solubility ratio was 10,000:1. The results in Table VIII with short-chain aliphatic acid salts is typical of those obtained.

The higher water solubility of the di(phenylmercuric)-ammonium series can be taken as an indication of a relatively higher degree of polarity. Solubility comparisons in benzene confirmed this in that the di-(phenylmercuric)-ammonium compounds were considerably less soluble in this nonpolar solvent than were the phenylmercurials.

The practical utility of this property can be demonstrated by a time-solubility study carried out with phenylmercuric acetate and di(phenylmercuric)-ammonium propionate. The general technique was to add 100 g. of the solid (ground to a 200-mesh size) to a beaker containing 1000 cc. of vigorously stirred tap water. Samples were removed at intervals from 1 to 60 min. and analyzed. The results were plotted in Fig. 1.

The addition of solid di(phenylmercuric)-ammonium propionate results in rapid solubility so that the entire strength of the slimicide will be rapidly available in much the same way as that obtained with a liquid composition. Phenylmercuric acetate dissolves much more slowly even in the high ultimate dilutions which are found in the system. This slower release of activity into the solution acts contrary to the massive shock theory which has been reported (*9*, *10*, *11*) to give more efficient and more economical control than continuous small additions.

SCREENING AND EVALUATION

The problem of testing several hundred mercurials which were available from the research laboratories was simplified to a great extent by preliminary chemical and physico-chemical screening.

Compounds with intensive color or offensive odors were eliminated from consideration lest these properties be imparted to the pulp during treatment.

Volatile products such as the lower alkyl mercurials were rejected because of excessively high vapor pressure which would add to the hazards of handling and

Table VIII

Compound	Water solubility at 25°C.[a]
Phenylmercuric acetate	0.20
Phenylmercuric propionate	0.42
Phenylmercuric butyrate	0.22
Phenylmercuric methacrylate	0.25
Di(phenylmercuric)-ammonium acetate	7.5
Di(phenylmercuric)-ammonium propionate	6.1
Di(phenylmercuric)-ammonium butyrate	5.0
Di(phenylmercuric)-ammonium methacrylate	2.6

[a] Reported as g./100g. of solution.

which might result in loss from the system by volatilization, particularly during the warmer summer months. The water solubility of all compounds remaining was determined and this was taken as an indication of the relative polarity of the product. Most organo-mercurials are extremely insoluble in water and an arbitrary standard was set to reject any compounds less than 3% soluble in water. Relative solubilities were determined by suspending 5 g. of the compound in 50 cc. of distilled water. The mixture was warmed to 35°C. on a water-bath with good mechanical agitation, cooled to 25°C., filtered, and analyzed.

MICROBIOLOGICAL EVALUATION

Methods and Materials

Test Organisms

Aerobacter aerogenes (a nonspore-forming bacteria) I.P.C. No. 500
Bacillus mycoides (a spore-forming bacteria) I.P.C. No. 509
Aspergillus niger (a fungus) I.P.C. No. 144
Penicillium expansum (a fungus) I.P.C. No. 126

These organisms were used because they are representative of those types most commonly associated with slime problems in pulp and paper mills (*12, 13*).

The compounds were tested by an agar-Petri dish method used at The Institute of Paper Chemistry (*14*). This method, although we were aware of its limiting effects on phenylmercurials as noted by Conkey and Carlson and confirmed by Cohen and Kalm (*14, 15*), was chosen because of its wide acceptance throughout the industry.

The nutrient medium used for growing and testing the bacteria was bacto-tryptone glucose extract agar.* For the fungi bacto-malt extract-bacto agar was used. Stock solutions of the test compounds were prepared on a weight-weight basis using distilled water as the solvent. Predetermined amounts of the stock solutions were added to each dilution bottle and three replicate plates were poured for each concentration tested. Since phenylmercuric acetate is used as a standard in the testing procedure a duplicate series of plates was prepared for each test level using a pharmaceutical grade of phenylmercuric acetate. This was done to act as a control and as a check on the sensitivity of the test organisms.

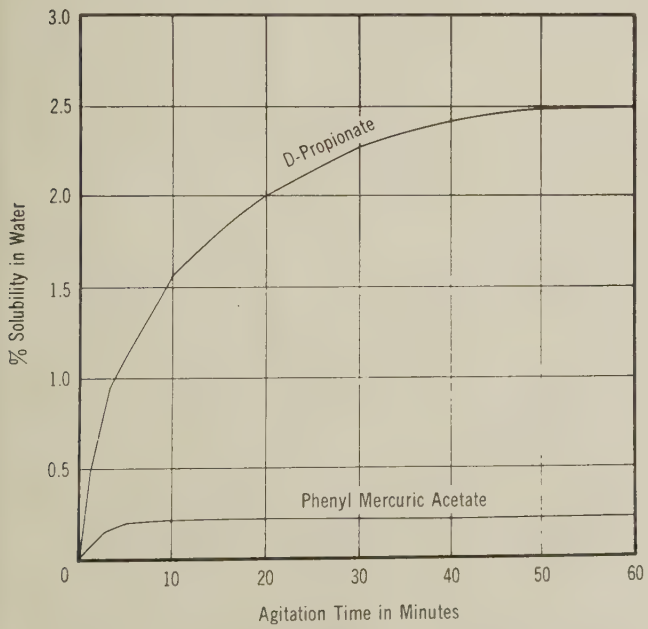


Fig. 1. Time-solubility comparison

It was apparent from the results of chemical screening that only a few of the compounds tested possessed properties required for a good slimicide. However, considerable preliminary microbiological screening was carried out in an effort to determine the general order of activity of the many types of compounds available. Table IX lists the results obtained in a comparison study between the di(phenylmercuric)-ammonium aliphatic acid salts and the analogous phenylmercury salts. Additional data on many other salts will be presented at a future date.

Although all of the compounds demonstrated a high order of antimicrobial activity, the di(phenylmercuric)-ammonium salts, particularly the acetate, propionate, and methacrylate, were the most effective. Exhaustive investigation of these three compounds revealed that the propionate best combined the properties of high antimicrobial activity, high water solubility, and marked resistance to deactivation, all of which were considered prerequisites for a good slimicide.

Activity Comparison of Di(Phenylmercuric)-Ammonium Propionate with Several of the Most Commonly Used Slimicides

Six commercially available toxicants including mercurials, nonmercurials, and mixtures of both were selected for comparison. For this particular study the materials were evaluated at concentration levels of 100 20, 10, 2.0, 1.0, 0.2, and 0.1 p.p.m. No attempt was made to pinpoint the exact minimum inhibiting con-

* Difco.

Table IX

Compound tested	Inhibiting concentrations[a] — Test organisms: Aerobacter aerogenes	Bacillus mycoides	Aspergillus niger	Penicillium expansum
D[b]-acetate	1.00	0.17	2.50	0.25
PM[c]-acetate	1.50	0.20	2.00	1.42
D-propionate	1.00	0.17	2.50	0.20
PM-propionate	1.40	0.17	3.33	0.20
D-butyrate	0.50	0.33	2.00	0.33
PM-butyrate	0.50	0.25	3.33	0.33
D-methacrylate	0.50	0.17	3.33	0.25
PM-methacrylate	1.00	0.17	3.33	0.25
D-stearate	1.40	0.50	3.33	2.00
PM-stearate	1.00	0.33	2.50	1.11
D-myristate	0.50	0.33	2.50	1.00
PM-myristate	1.00	0.50	2.50	1.42
D-2 ethyl hexanoate	1.00	0.33	2.50	1.00
PM-2 ethyl hexanoate	1.00	0.33	2.50	1.00
D-undecylenate	1.00	0.50	2.50	1.00
PM-undecylenate	1.00	0.33	2.50	1.00
I.P.C. PM-acetate	2.00	0.20	5.00	6.00

[a] Results expressed in p.p.m.
[b] D = di(phenylmercuric)-ammonium.
[c] PM = phenylmercuric.

Table X

Inhibiting agent	Inhibiting concentrations[a] — Test organisms: Aerobacter aerogenes	Bacillus mycoides	Aspergillus niger	Penicillium expansum
Product A	>2.0	>2.0	>10.0	>10.0
Product B	>20.0	>2.0	>100.0	>100.0
Product C	>20.0	>2.0	>100.0	>100.0
Product D	>10.0	>2.0	>100.0	>100.0
Product E	10.0	0.5	>10.0	>10.0
Product F	2.0	0.33	2.0	1.42
D-propionate	1.0	0.16	2.5	0.20

[a] Inhibiting concentrations p.p.m.
Product A = a mixture of PMA and potassium 2,4,6-trichlorophenate.
Product B = a brominated nonmercurial.
Product C = an alkoxy-mercurial.
Product D = a nonmercurial.
Product E = a mixture of PMA and carbamates.
Product F = phenylmercuric acetate (PMA).

centration with the exception of phenylmercuric acetate and di(phenylmercuric)-ammonium propionate. (The latter two materials were more thoroughly investigated to serve as a basis of comparison between this study and others currently in progress in this laboratory.) The results as listed in Table X prove conclusively that di(phenylmercuric)-ammonium propionate is more effective in the laboratory for the inhibition of these four slime-producing organisms than any of the other materials tested. Mill tests were set up to determine whether or not this high order of activity would be successfully maintained under actual operating conditions.

Mill Trials

Initial studies were made at a high-grade paper mill using bleached kraft hardwood pulp. Considerable difficulty had been reported in maintaining the machines free from slimy deposits despite frequent and thorough cleanups with brushes and high-pressure hoses. Several slimicides had been tried including various phenylmercurials but none afforded the necessary protection.

Machine no. 4, run without any slimicide because of the many cleanups necessitated by frequent changes in color and stock, and because of fear of incompatibility of slimicide with colors, made an ideal, untreated control. Machine no. 5 had previously been treated with a solid composition containing phenylmercuric acetate and a nonmercurial at a dosage of 7¢ per ton of finished product. The procedure in this mill was to add the

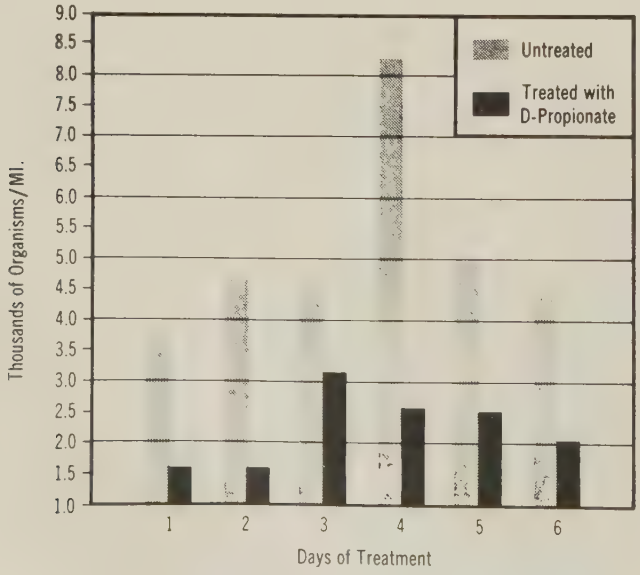


Fig. 2. Evaluation of D-propionate in kraft mill

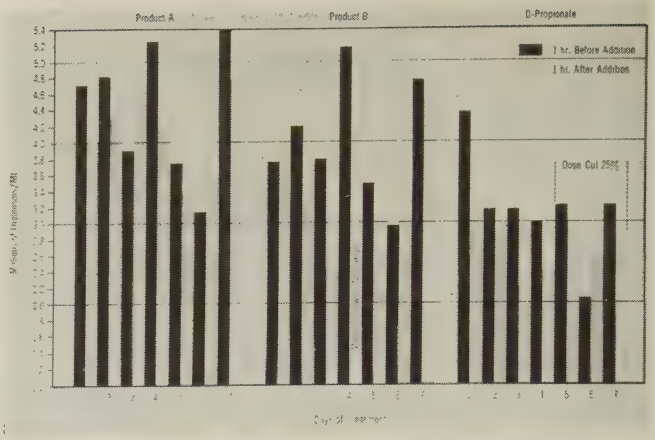


Fig. 3. Cost efficiency study at equal initial cost

toxicant in three equal portions at 8 hr. intervals to the beaters where the recirculated white water was added to the pulp to prepare the stock. This white water probably is the greatest source of contamination in this mill. To minimize operating problems the di-(phenylmercuric)-ammonium propionate was added as a solid in dispersible envelopes at exactly the same cost per ton and in exactly the same manner as the previous slimicide.

Samples of white water were collected from the wire pits of both machines. The time of sampling was arbitrarily chosen as 1 hr. after the morning addition of toxicant. Plate counts were made on the samples for 6 days and the results are reported in Fig. 2.

Thorough daily inspections of both systems yielded information which is probably more significant than bacterial counts. The no. 4 machine, after 2 days of operation, had a slimy layer on the surfaces of boxes and chests, and was especially heavy on the walls of the saveall tank. Scratches made in the trays under the fourdrinier were completely covered by slime growth. Two wooden panels 6 × 6 in., suspended in the headbox, showed slime formation. Even after repeated washups the slime continued to accumulate rapidly. The no. 5 machine was completely free of slime buildups even after the sixth day. The walls and surfaces of boxes, chests, and saveall tank were completely clean. The suspended wooden panels and scratched

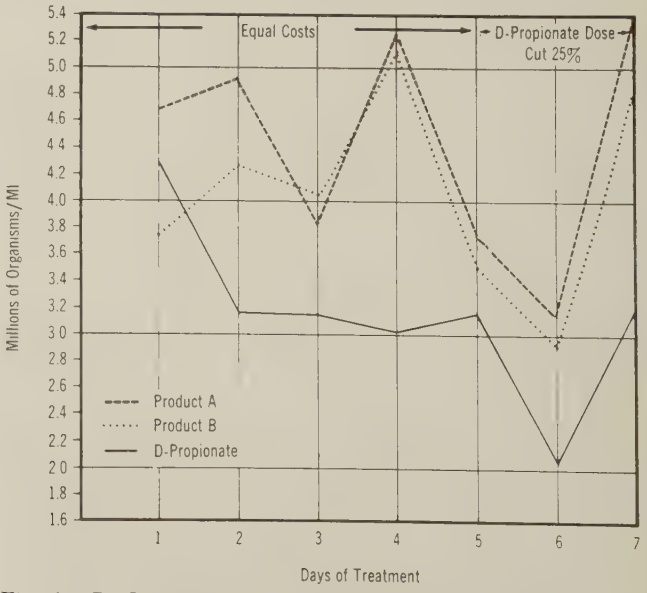


Fig. 4. Daily count of organisms 1 hr. before addition of slimicides

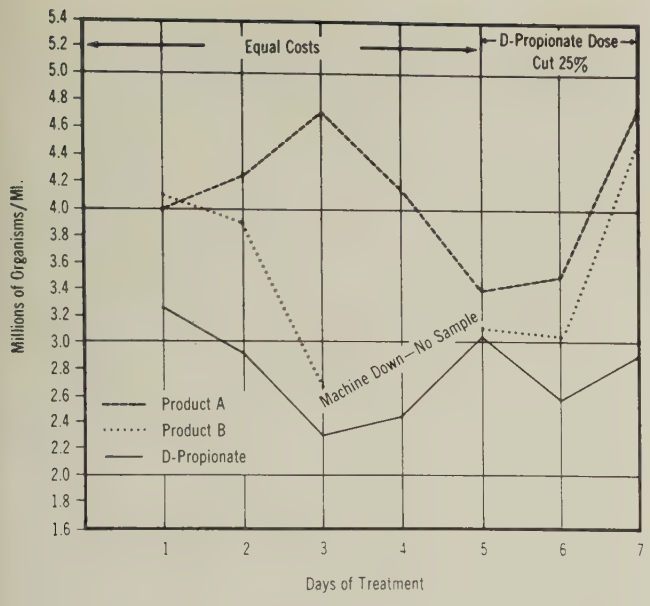


Fig. 5. Daily count of organisms 1 hr. after addition of slimicide

trays remained totally slime free. The overall efficiency of the no. 5 machine was greatly increased due in part to time saved by fewer washups and also to a decrease in the quantity of rejected paper. It had been necessary with other slimicides to reject the first two or three rolls of paper due to numerous slime spots immediately following a washup. Since the initial treatment with di-(phenylmercuric)-ammonium propionate, this problem has disappeared. After 8 weeks of continued treatment, both machines were re-sampled. No significant change was noted from the data obtained during the initial study. The bacterial population of the no. 5 machine was still 50% below the level of the no. 4 machine. This sustained control afforded by treatment with di-(phenylmercuric)-ammonium propionate is an indication that the slime forming organisms have not become immunized or acclimatized to this product.

The next mill evaluation was undertaken at a newsprint mill using a mixture of groundwood and sulfite pulps. Here the problem of slime control was, as expected, more difficult than those encountered in the first plant study since groundwood has long been recognized as one of the major sources of slime-producing organisms.

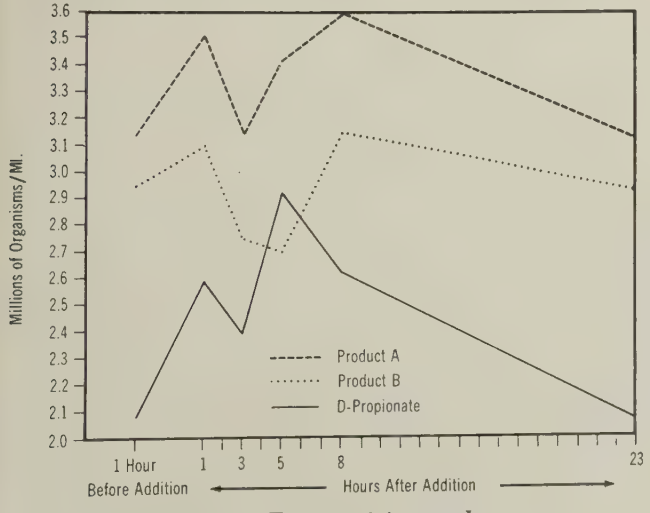


Fig. 6. Time activity study

This mill afforded an unusual opportunity for obtaining information in that two slimicides, a phenylmercurial-chlorinated phenol mixture (Product A) and a nonmercurial (Product B), were being used concurrently. Since this mill preferred a liquid treatment, an aqueous solution of di(phenylmercuric)-ammonium propionate containing 6% mercury (equivalent to 9.6% active compound) was used for comparison with the liquid products, A and B, which had been evaluated in this laboratory and reported, with the same designations, in Table X.

This mill used the slug-treatment with slimicide incorporated once every 24 hr., usually in the early afternoon. Products A and B were being used at a dosage equal to approximately 15¢ per ton of finished newsprint and, for the first 4 days of the trial, the di(phenylmercuric)-ammonium propionate was added at the same cost level. Samples were taken from each of the three machines 1 hr. before and 1 hr. after treatment. After 4 days of treatment the plate counts indicated that the di(phenylmercuric)-ammonium propionate was giving a considerably higher degree of protection than either Product A or Product B and the dosage was cut 25% for the remainder of the study, the results of which are reported in Fig. 3.

A plot was made (Fig.4) of the number of organisms per milliliter found in each machine 1 hr. before the addition of toxicant versus days of treatment. This is a good indication of the sustained protection offered by each of the three slimicides during the period between treatments. Figure 5 on the other hand, represents the immediate or "quick-kill" effect of each of the toxicants 1 hr. after addition. It can be seen readily that the di(phenylmercuric)-ammonium propionate, even at a 25% decreased cost, exhibits the highest degree of overall protection by a combination of "quick" and sustained kill.

It was of interest to us at this point to determine the variations in levels of protection offered by each of the three products at different intervals during a 24-hr. period between additions, with the di-(phenylmercuric)-ammonium propionate at a 25% reduced dosage level. Samples were taken 1 hr. before addition and 1, 3, 5, 8, and 23 hr. after addition. The results, as presented in Fig. 6, further demonstrate the superior effect of di-(phenylmercuric)-ammonium propionate in maintaining a low bacterial count in a mill system despite the tendency of the bacterial flora to re-establish itself.

The data obtained from these two, brief, mill tests are, of course, only preliminary in nature. Additional mill trials are being carried out on a widely expanded basis to further evaluate this extremely interesting and highly potent slime control agent.

CONCLUSIONS

1. The di(phenylmercuric)-ammonium compounds are, as a series, relatively water soluble and highly active toxicants.

2. Di(phenylmercuric)-ammonium propionate has proved to be one of the most powerful antimicrobial agents yet reported when tested against slime-producing organisms.

3. Preliminary evaluation studies in two paper mills corroborates the laboratory data which indicated that di(phenylmercuric)-ammonium propionate is con-

siderably more effective than several of the products which have, to date, been most successfully and widely used in the paper and pulp industries for the control of slime.

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New Coating Preparation Plant at Blandin Paper Company

C. A. RICHARDSON

New facilities are described for unloading bulk clay from hopper cars, for preparing and storing 70% clay slip, for screening the clay and starch before cooking, and for preparing the coating color. The clay is unloaded by a Cyclo-Vac system, which is basically a vacuum unloader combined with a centrifugal separator. The clay is made down as a 50-ton batch by a curved blade turbine agitator. The clay storage consists of agitated, epoxy-resin lined tanks each holding 110 tons. For the coating preparation, the clay slip and then the starch slurry are screened through a 230-mesh screen into a mixing tank, and the mixture is then cooked instantaneously with steam through a Hasco heater. After agitation the color is screened into storage and then pumped hot to the coater supply tanks. It is cooled as it then circulates to the coating heads.

Shortly after the startup of the trailing-blade coater on publication grades at the Blandin Paper Co., it became apparent that factory-converted starches and relatively high viscosity coating colors would be used. At the beginning, the coating was prepared in the conventional manner by cooking the starch in a batch tank using direct steam and blending the thick paste with 70% clay slip. In making coating colors of higher viscosities, the starch pastes became very thick and difficult to handle, and a considerable amount of paste was left behind in the cooker tank.

Continuous cooking of the starch mixed with the clay offered several advantages: coating colors of a wide range of solids and/or viscosities can be prepared by the proper choice of starches; there is no unpumpable starch paste remaining, and there is probably more efficient use of the adhesive by cooking in intimate contact with the pigment.

Commercial trials confirmed the operating advantages, and printing trials showed that while definite superiority of continuously cooked coatings could not be proved, they were fully equal in all respects to coatings prepared in the conventional batch manner.

Continuous cooking operations were carried out for several months in a temporary arrangement using available tanks and pumps. Sack clay was used at first, with 70% clay slip purchased in tank cars later. The mixture of clay and starch was cooked by passing through a Hasco heater into a blending tank, then pumped to storage tanks and finally through a Sweco screen into the coater supply tanks.

Plans were then made for the construction of a new coating preparation plant to include facilities for unloading bulk clay from hopper cars, for preparing the storing of 70% clay slip, for screening the clay and starch before cooking, and for preparing the coating color for one coater, with expansion plans to take care of a second coater. The following is a description of the installation:

CLAY UNLOADING AND MAKE DOWN

The clay unloading is accomplished by a "Cyclo-Vac" system manufactured by the Superior Separator Co. The "Cyclo-Vac" is basically a vacuum unloader combined with a centrifugal separator. The clay is conveyed from a lightweight, aluminum car adapter through a 5-in. pipe to the "Cyclo-Vac" by a Nash L-6 vacuum pump driven by a 50-hp. motor. The vacuum created in the system (generally about 15 in.) draws clay and air from the chopper car and conveys them into the separating chamber. Inside the unloader the clay is separated from its air carrier and is discharged from the bottom by means of a rotary air lock.

The clay-air separation is accomplished in three stages. The first separation takes place when the clay and air first enter tangentially into the bottom cone. Here the bulk of the heavier particles spiral downward toward the rotary airlock. The air and finer particles then travel upward to the secondary separating zone which consists of a louvered rotor driven at 750 r.p.m. by a 5-hp. motor. The rotation and the design of the louvers impose centrifugal force on the particles and throw them toward the outer shell of the separator. The particles circulate in this area until they agglomerate and gain sufficient weight to drop downward to the rotary valve. The third separation process occurs at the center of the rotor where the finest particles are separated. The design of the rotor produces a product-free vortex at its center. The extremely fine particles

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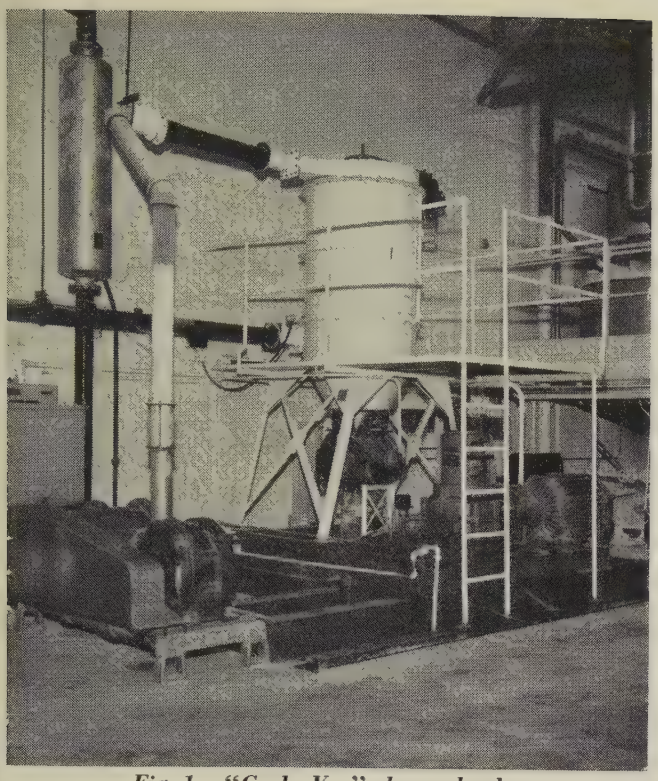

Fig. 1. "Cyclo-Vac" clay unloader

when escaping the second separation circulate around the vortex until they agglomerate and accumulate enough density to pass through the rotor louvers into the second zone. The clean air, following the third stage, moves out through the top of the rotor to the vacuum pump. About 17 gal. of seal water per minute are used on the pump, and the clay escaping the separator is trapped in it. The water contains only about 3 lb. of clay per 1000 gal. Since there is no evidence of clay in the air exhausted from the vacuum pump, the separation is practically perfect. Figure 1 shows an external view of the "Cyclo-Vac" unloading system. The clay-air mixture enters the bottom pipe, and the air leaves at the top. In the foreground is the drive of the clay make-down agitator.

The rate of unloading varies considerably with the vendor; different clays varying very much in their conveying properties. The shortest time for a 50-ton car is $2^{3}/_{4}$ hr., or a rate of 18 tons per hour. A typical unloading time is between 5 and 6 hr., including time for attaching the car adapter and vibrator.

From the rotary valve the clay drops directly into a 13-ft., stainless steel make-down tank where it is made into a 70% slip. The tank is large enough to accommodate a 70-ton car of clay, but we have standardized on 50-ton cars.

The dispersion is accomplished with a curved blade turbine agitator manufactured by the Mixing Equipment Co. Two 5-blade turbines are mounted on a shaft located in the center of the tank. The shaft is held by a steady-rest bearing at the bottom. The agitator is driven by a 75-hp. motor at peripheral speeds of 1600 and 1765 f.p.m.

The procedure in making-down a car of clay is to meter water into the tank sufficient to make a 71% slurry from a 50-ton car. The agitator is started and 200 lb. of tetrasodium pyrophosphate are added to the water to insure a maximum dispersion of the coating color after the clay slip is mixed with the starch. This is necessary even with the predispersed clay, since converted starches will rob the phosphate from the clay. The unloading is then started, and the maximum unloading rate is maintained right up to the last clay from the car. As soon as the dust has cleared in the tank, the floating lumps are broken up with a long pole, and the mixing is then continued for about 6 hr. to insure complete dispersion. After dispersion is complete, a solids test is made and water is added to bring the solids down to 70%.

Several tests on batches of clay from three different suppliers showed that dispersion is complete in less than 2 hr. after the clay is all in, and the lumps are broken up. A determination of the residue on a 325-mesh testing screen was used as a measure of dispersion.

Clay Storage

The clay storage consists of three agitated tanks, each holding about 110 tons of clay at 70% slip. The tanks are about 14.5 ft. sq. and have a liquid level of 13 ft. They are made of poured concrete with epoxy resin linings. Each is agitated by a flat blade turbine agitator supplied by the Mixing Equipment Co. The 48-in. diameter turbines are rotated by 10-hp. motors. The agitators are equipped with stabilizing rings, no bottom bearings are used.

The clay slip is conveyed from the make-down tank to storage by a Moyno pump at the rate of 50 g.p.m.

COATING PREPARATION

Two lines of tanks for the preparation of the coating color are installed in parallel, one being used for the top side color, and the other for the wire side color. By the addition of two storage tanks and a screen the two lines will be used to supply two coaters. Two additional clay storage tanks are poured and lined ready for agitators and piping when needed for more capacity.

Stainless steel is used throughout the system for all tanks, piping, and agitators to insure a minimum of contamination. All of the tanks, except the starch slurry tanks, have a capacity of 1000 gal. Moyno pumps are used throughout the plant, except for the starch slurry. They are all operated at 450 r.p.m. or less, and have given no unusual maintenance troubles. The agitators were all supplied by the Mixing Equipment Co. Propeller-type agitators are used on the uncooked clay and starch, and flat blade turbines on the cooked coating color. All of the tanks have four baffles to aid the agitation.

Each line starts with a mixing tank equipped with a propeller-type agitator. The proper volume of 70% clay is pumped from storage into the mixing tank through a 230-mesh Sweco screen at the rate of 50 g.p.m. The volume of clay is regulated by a timer—the operator starts the pump and the timer shuts it off. The volume of clay is checked by the operator by measuring the distance from the top of the tank to the clay after the pump has stopped.

One Sweco screen is used alternately for both lines. In supplying coating color for one coater, the screen has been operated approximately $2^{1}/_{2}$ hr. per day for 18 months (or a total of over 10,000 hr.) without changing the 230-mesh wire.

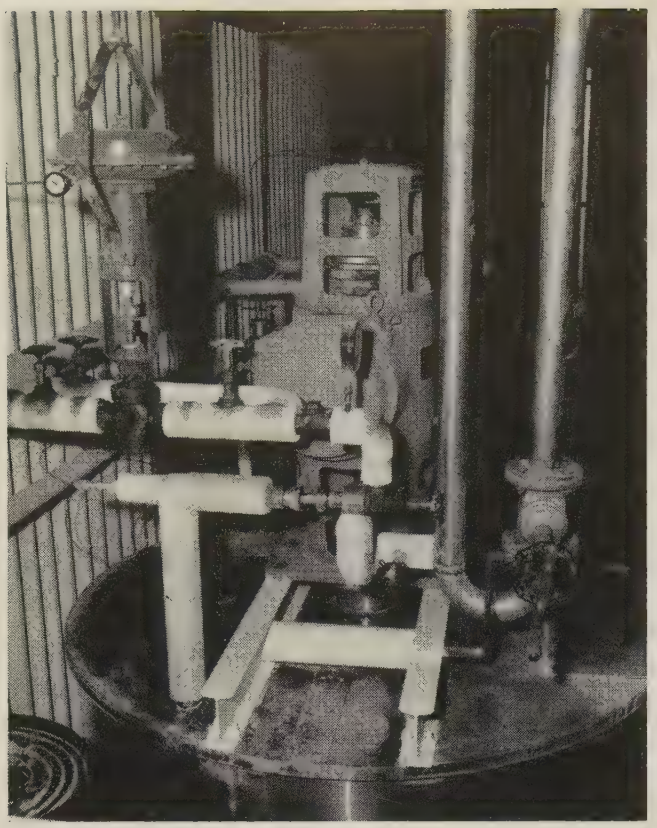

Fig. 2. Piping arrangement to the Hasco heater

The starch slurry tank is equipped with an agitator identical with those in the mixing tanks. The proper amount of water to produce the desired coating solids after cooking is metered into the tank and the dyestuff added. The starch is added with the pump circulating the water and starch back into the tank to prevent settling of the starch in the pump inlet. After a few minutes agitation, the starch slurry is pumped into the mixing tank through the 230-mesh Sweco screen. The starch pumps are Marlow centrifugal pumps having a capacity of 40 g.p.m.

The mixture is agitated thoroughly and then circulated to the Hasco heater and back to the mixing tank at the rate of 23 g.p.m. About 12 g.p.m. are passed by the heater and the surplus goes back to the mixing tank.

The cooking reaction takes place instantaneously in the combining tube of the Hasco heater as the clay-starch slurry meets 125 lb. steam as it passes through the cooker tank. The cooked mixture falls into the tank and accumulates there until the batch has all been cooked through the heater. The agitator is started as soon as it is covered, and the mass is thoroughly agitated for at least 1 hr. During this time the temperature drops only slightly and any cooking not completed at the heater is completed here. Several tests have shown that holding the color at high temperatures under agitation for several hours has little or no effect on the viscosity.

The temperature is controlled by a Bailey instrument operating a control valve on the steam line to the heater. The bulb of the temperature transmitter is located in a T immediately after the heater, and is protected from erosion by the clay by a layer of sprayed on Stellite. The rate of flow through the heaters is regulated by adjustment of the combining tube to keep the steam valve approximately in the center of its travel.

Figure 2 shows the piping arrangement to the Hasco heater. The clay-starch slurry is circulated from the mixing tank through the loop past the heater and back to the tank. The valve in the lower right corner is partly closed to force the slurry through the heater. The thermometer bulb is shown below the steam valve.

Other components of the coating color are added to the batch in the cooker tank while the mixture is being agitated, or they may be added to the mixing tank ahead of the heater.

The batch is next pumped through a 60-mesh Sweco screen into the agitated storage tank. The pump capacity can be varied from 16 to 48 g.p.m. by a Reeves drive so that colors of high viscosity can be screened. This screen is used alternately for the two preparation lines.

The color is pumped from the storage tank through insulated pipes to the coater supply tank by a 50-g.p.m. pump. The supply tank is equipped with a Fielden "Tektor" probe which shuts off the storage tank pump when the predetermined high level is reached. At frequent intervals the operator starts the pump manually from the panel board in the preparation plant and it is shut off by the probe. The frequent pumping, together with the pipe insulation, keeps the color in the pipe hot enough to prevent set-back which could plug the pipe.

The supply tank is equipped with a flat blade turbine similar to the one on the storage tank.

The coating color is circulated to the coating heads by a 20 g.p.m. pump. The color is regulated into the coating head by a level controller and the surplus returns to the supply tank. There is no overflow at the head so there is no re-screening problem.

The coating is cooled in the pipes circulating to the coating head and again in the return line. The coolers consist of copper tubing bent into an approximate sine curve and inserted inside the 3-in. stainless steel line carrying the coating. Cold water is passed through the copper tube. Heat removal is surprisingly good, over 30,000 B.t.u. per hour in a 30-ft. length pipe, using $^1/_2$-in. copper tube with water at 44°F.

This system of coating preparation has been used so far to prepare coating colors from 38 to 62% solids, all at the fairly high viscosity required for trailing-blade coating. No attempt has been made to prepare higher solids but there is no reason why, with 73% clay slip and suitable starches, a coating color of at least 68% could not be made.

The preparation plant has fully lived up to expectations. One operator per shift prepares the coating for one coater and unloads two cars of clay per week. It is expected that the single operator will be able to prepare coating for two coaters, while one day man will operate the clay unloading system and the projected bulk starch handling facility. The methods used produce constant solids and adequate viscosity control in the coating color at the coater, and the system has the desired flexibility.

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Relationships Between Wood Density and Other Wood and Pulp Properties

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In connection with a tree improvement program the effects of variations in wood density, within and among slash pine trees, have been studied. Within trees, variations in wood density are accompanied by variations in springwood-summerwood ratio, pentosans content of wood and pulp, and alpha-cellulose content of pulp. Between trees, none of the above properties appear to vary consistently with wood density, but between-tree variations in wood density are indicated to be related to changes in the cross-sectional dimensions of both the springwood cells and the summerwood cells. Variations in paper strength properties with wood density variations within a tree are greater than those caused by wood density variations between trees. It is concluded that specific gravity should be considered a factor in plus tree selection only to the extent that it influences wood (and pulp) yield. Additional studies may lead to a combining of specific gravity, springwood percentage, pentosans content, and alpha-cellulose (and possibly other factors such as fiber strength) into a pulp quality term which can be evaluated in judging tree superiority.

ONE major aspect of the forest genetics program of the Buckeye Cellulose Corp., a participant in the Cooperative Tree Improvement Program of the University of Florida, is the selection of superior trees as a future, genetically pure seed source. The central Gulf Coastal region, where most of the Buckeye forests are located, is particularly well suited to such an approach to tree improvement. A relatively uniform climate and topography allows initial selections to be made largely on phenotype, and characteristics of a plus tree which cannot be laid to its peculiar environment are assumed for the present to be genetically influenced.

Selection is based on a scoring system which requires that candidate trees have a greater cordwood volume than the average of the ten nearest dominant and codominant trees of the same age, with a correction being made for any crown area advantage of the selected tree.

The average Buckeye selection, slash pine (*P. elliottii* Engelm.), is about 10 ft. taller and 123% larger in volume than its neighbors of the same age. Also, selected trees have been found to have 25% more crown area than adjacent trees. Other factors influencing the final tree score are straightness, branch diameter, natural pruning, wood density, and height.

In the tree scoring, high wood density (ovendry weight per unit green volume of wood) is considered a plus factor. The advantages of greater wood yield per acre and increased digester loading from higher density wood are obvious. However, because of the significance of this program to the future wood supply of the company, it was felt that any effects of wood density on pulp quality should be considered. As a consequence of this thinking, the Buckeye Technical Forestry Department proposed a study to determine any possible relationships between wood density and the quality of both dissolving-grade and paper-grade pulps. Such a study was undertaken with the work on paper-grade pulps being reported here.

A number of reports may be found in the literature concerning the interrelationships of tree growth characteristics, wood properties, and pulp properties. Notable among these are the offerings of the Forest Products Laboratory which date back many years. An excellent review of this literature is provided in the recent paper by Wangaard (*1*). Professor Wangaard points out that most American data relating wood and pulp properties have been expressed as relationships between pulp properties and springwood-summerwood ratio rather than wood density directly. In the present work specific gravity variations within and between slash pine trees are related to variations in other wood and pulp properties, both physical and chemical.

PROCEDURES

Field procedure for the wood density-pulp quality study consisted of randomly selecting 137 specimen trees occurring within a gross area of 500,000 acres centered around Taylor County, Fla. An effort was made to stratify by townships the entire acreage sampled. In order to reduce possible site and age variables, diameters were confined to 7 through 10-in. classes and sites restricted to the common flatwoods condition. Extremes of stand density and growth rate were not sampled. As a final criterion, all trees had to be of average straightness with no other noticeable stem defects.

Radial cores were extracted at breast height with a sharp, 6-in. by 0.157-in. increment borer and placed immediately in a vial of water. Specific gravity determinations were based on calculated green volume and ovendry weight of the woody portion of the core exclusive of the first two or three dim rings adjacent to the pith. From the first 100 observations, three trees, representing the mean and extremes of wood density found, were selected for this study. These trees, each 18 years old and designated L (low), A (average), and H (high), had increment core specific gravities of 0.488, 0.564, and 0.655, respectively. Each tree was cut into ten 4-ft. logs, and disks were sawn from each log at time of cutting for moisture and specific gravity

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determinations. Springwood-summerwood ratios and cell cross-sectional dimensions were measured on some of the disks. For pulping, each tree was divided into three approximately equal weight portions, comprised of logs 1 and 2; 3, 4, and 5; and 6, 7, 8, 9, and 10, respectively, numbering from the stump. Inadvertently, log number 8 was chipped with logs number 4 and 5 of tree H; the batches for this tree are comprised of logs 1 and 2; 4, 5, and 8; and 6, 7, 9, and 10, respectively. Chemical analyses were made on each of the nine batches of wood.

Table I. Pulping Conditions

Forced Circulation, Indirect Heating	
Steaming time	120 min.
Maximum pressure	90 p.s.i.g. (331°F.)
Time at maximum pressure	90 min.
Active alkali	19% Na_2O, dry wood basis
$NaOH/Na_2S/Na_2CO_3$	65/25/10 Na_2O basis
Liquor/wood	4.5/1 (wood moisture included)

Conventional sulfate cooks as outlined in Table I were used to pulp the several batches. The unbleached pulps were subjected to chemical analysis, fiber length measurement, and springwood-summerwood ratio determinations. Paper strength tests were made on TAPPI Standard handsheets prepared from pulp beaten in a Noble & Wood cycle beater.

Fig. 1. Wood density versus position in tree

WOOD PROPERTIES

Wood specific gravity and moisture data are tabulated in Table II along with other pertinent data. The breast-height increment core specific gravity is shown to be roughly equal to the weighted average specific gravity for each tree.

Specific gravity data for the three trees are plotted in Fig. 1. Similar patterns of decreasing specific gravity from butt to top are noted in all three trees. It is interesting to note that the average specific gravity

Table II. Wood Data

Disk no.	Tree L Diameter, cm.	Tree L Moisture, %	Tree L Specific gravity	Tree A Diameter, cm.	Tree A Moisture, %	Tree A Specific gravity	Tree H Diameter, cm.	Tree H Moisture, %	Tree H Specific gravity
1	23.1	42.3	0.508	20.6	39.5	0.592	21.5	36.8	0.641
2	17.9	44.5	0.518	15.2	38.2	0.617	15.0	34.3	0.683
3	17.5	47.2	0.490	15.0	40.4	0.599	14.5	38.3	0.636
4	16.9	47.6	0.481	14.3	42.5	0.574	14.1	39.5	0.614
5	16.6	49.3	0.455	13.7	43.4	0.565	13.6	41.8	0.614
6	16.0	53.0	0.439	13.0	44.5	0.544	12.9	43.5	0.574
7	15.1	54.4	0.424	12.3	44.6	0.541	12.2	46.4	0.551
8	14.1	55.4	0.421	11.4	45.4	0.541	11.4	48.4	0.551
9	13.2	58.4	0.411	10.5	47.4	0.534	10.2	49.8	0.543
10	11.6	60.0	0.405	10.0	46.1	0.560	9.5	48.9	0.568
11	9.9	62.1	0.387	7.9	51.1	0.505	7.7	53.5	0.504
Weighted average for tree			0.460			0.580			0.609
Increment core specific gravity			0.488			0.564			0.645
Tree age at breast height, yr.			18			18			18

The disks are numbered from the butt end of the butt log (no. 1) to the top end of the top log (no. 11). Diameter is inside bark. The increment core was taken at breast height or about the position of disk no. 2.

Test procedures employed are listed below:

Wood

Hot water solubility: TAPPI T 1 m-54.

Pentosans: Buckeye method A-38 (differs from TAPPI method in that instead of precipitation of furfural with phloroglucinol, furfural is read on spectrophotometer).

Lignin: Buckeye method A-39 (essentially as TAPPI method except hydrochloric acid added as wetting agent).

Alcohol-benzene extractives: TAPPI T 6 m-54.

Pulp

Permanganate number: TAPPI T 214 m-50.

Alpha cellulose: Buckeye method A-1 (pulp is extracted in 17.5% NaOH, diluted to 8.3% and filtered. Filtrate oxidized with dichromate to determine beta plus gamma. Alpha is determined by difference).

Lignin: Buckeye method A-39.

Pentosans: Buckeye method A-38.

Hot alkali solubility: Buckeye method A-53 (proposed method of ACS Division of Cellulose Chem., April, 1950).

variation within a tree approximates the variation found between trees at a given height. It was found that similar curves were obtained when dry-weight percentage (in the freshly-cut wood) was plotted against position in tree; high moisture content was associated with low specific gravity.

Chemical analyses of representative samples of each of the batches of chips from which pulps were prepared are listed in Table III. Except in the case of pentosans, there appears to be no relationship between these chemical properties and wood density. Within a tree, pentosans content increases as specific gravity decreases, but pentosans content is not related to wood density between trees.

If it is assumed that the specific gravity of solid wood substance is essentially constant then wood density must be determined by the amount of void space in the wood, which, in turn, is related to the cell geometry (cell wall thickness and cell diameter). To demon-

Table III. Wood Chemical Properties

Tree	Position	Chip specific gravity	Hot water solubility, %	Pentosans, %	Lignin, %	Alcohol-benzene extract, %
L	Bottom	0.505	2.93	7.15	27.4	2.24
L	Middle	0.466	3.72	7.06	27.9	3.12
L	Top	0.415	5.98	7.83	27.8	3.50
A	Bottom	0.603	3.56	5.98	27.9	2.17
A	Middle	0.571	3.70	6.18	26.8	2.96
A	Top	0.538	3.18	6.53	27.7	2.82
H	Bottom	0.653	3.59	6.87	27.2	2.70
H	Middle	0.610	3.56	7.76	27.0	3.16
H	Top	0.549	2.50	7.87	28.2	2.21

strate the relationship of cell geometry to wood density the cross-sectional dimensions of 50 springwood cells and 50 summerwood cells in the last annual ring of disks from three positions in each of the trees were measured. Averages of these data are recorded in Table IV. Since the measurements of the cell cross sections are limited to a single annual ring, they can be considered only indicative of the cross-sectional construction of the tree. The indication is probably reasonably reliable, however, since other wood and fiber properties (specific gravity, fiber length, and fibrillar angle) have been shown by other investigators (*2*, *3*) to vary regularly with age of the tree. A general increase in the outside dimensions of both springwood and summerwood cells is noted as specific gravity decreases from tree to tree. Within a tree no such relationship is observed. Springwood cell walls appear to be thinner in the lower density trees, but summerwood cell wall thickness varies in no consistent pattern.

Measurements of springwood-summerwood ratios (volume) are also included in Table IV. These measurements, determined on three radii 120° apart, respect the entire stem cross section. Within a tree the springwood percentage varies considerably from butt to top with the higher springwood percentage occurring at the top. Some variation in per cent springwood at the same position is noted between trees. It can be generalized that between-tree variations in specific gravity are due mainly to differences in cell size and to a lesser extent to differences in per cent springwood, while within-tree variations in specific gravity are almost altogether due to differences in springwood percentage. It would appear then that little information relative to size and shape of fibers is afforded by measuring just specific gravity of the wood.

PULP PROPERTIES

Chemical properties of the unbleached pulps prepared from the batches of chips previously described are listed in Table V. Both pentosans and alpha-cellulose contents are seen to vary with position in tree, but neither property can be related to variations in specific gravity between trees. Lacking replicate cooks to establish reliability, the variations in permanganate number and lignin content are assigned to variations in cooking reproducibility. On the other hand, pulping experience has shown that permanganate number variations of this magnitude do not result in significant alpha or pentosans variations. No pattern of hot alkali solubility variation is noted.

Fiber length determinations were made on the pulps, both microscopically and on the Clark classifier. Counts of springwood and summerwood cells were also made. Results of these determinations are listed as Table VI. While the fiber length values obtained by the two methods differ in level, neither method shows differences within or between trees relatable to wood density. It is implied in a recent article by Jayme (*4*) that the higher tear resistance of pulp made from high density wood arises, at least in part, from the greater average fiber length of the high density wood. According to Jayme, higher basic specific gravity within the same species of wood results from a higher content of late wood cells which show a pronounced tendency to greater fiber length. The data of Table VI fail to indicate that the greater tear resistance of higher density wood is due to greater average fiber length. Further, no relationship is noted between content of late wood cells and fiber length.

Paper strength data at 650 ml. Canadian Standard Freeness are plotted in Figs. 2 and 3. Bursting strength (Fig. 2) is seen to be generally related in an inverse way to wood specific gravity, but within a tree the relationship greatly improves. As specific gravity decreases, bursting strength increases. Conversely, as specific gravity decreases, tearing resistance decreases (Fig. 3),

Table IV. Wood Cross Sections

Tree	Disk no.	Disk specific gravity	Average cell dimensions, microns — Springwood — Radial	Springwood — Tangential	Springwood — Wall	Summerwood — Radial	Summerwood — Tangential	Summerwood — Wall	Springwood-summerwood ratio (% of total volume)
L	2	0.518	61.5	62.1	3.3	33.1	58.5	9.0	60/40
L	6	0.439	56.5	65.3	3.5	28.3	60.5	8.3	69/31
L	11	0.387	56.3	60.0	3.5	28.6	51.3	8.8	80/20
		Average	58.1	62.5	3.4	30.0	56.8	8.7	
A	2	0.617	52.6	54.8	3.7	27.0	47.1	9.0	58/42
A	6	0.544	52.8	54.8	3.5	30.8	51.6	11.6	64/36
A	11	0.505	50.6	55.0	3.3	31.8	52.3	9.3	67/33
		Average	52.0	54.9	3.5	29.9	50.3	10.0	
H	2	0.683	40.8	51.5	4.2	25.4	49.9	9.8	52/48
H	6	0.574	48.8	58.6	4.5	27.0	49.9	9.5	65/35
H	11	0.504	48.1	54.5	3.8	22.5	49.8	7.2	79/21
		Average	45.6	54.9	4.2	25.0	49.9	8.8	

Table V. Pulp Chemical Properties

Tree	Position	Chip specific gravity	Permanganate number	Alpha-cellulose (corrected for lignin), %	Lignin, %	Pentosans, %	Hot alkali solubility, %
L	Bottom	0.505	28.0	95.5	5.4	6.3	4.9
L	Middle	0.466	24.4	94.3	4.5	7.0	5.7
L	Top	0.415	26.1	93.8	5.1	7.7	5.7
A	Bottom	0.603	25.9	95.6	4.8	5.6	4.0
A	Middle	0.571	24.4	94.5	4.1	6.4	6.1
A	Top	0.538	26.7	94.6	4.8	6.9	5.1
H	Bottom	0.653	31.3	96.0	6.6	6.9	6.9
H	Middle	0.610	23.8	94.8	4.4	7.1	6.3
H	Top	0.549	24.1	94.1	4.2	7.5	7.1

the decrease in tear with specific gravity being more marked within a tree. These general relationships of wood density and position in tree to paper strength are well known. Pulps made from higher density southern softwoods generally have higher tear and lower burst than pulps made from lower density, northern softwoods. Other factors influencing these general relationships are indicated by the variation in other wood and pulp properties with specific gravity variations within and between trees.

DISCUSSION

Because of the limited number of trees involved in this study, the observations made cannot be considered as representing a statistical sampling of slash pine. However, the rather intensive characterization of the selected trees of varying wood density offers possible additional criteria for assessing the pulp-making quality of a tree. Since specific gravity variations within a tree have greater effects on paper strength properties than between-tree variations, consideration of other wood and pulp properties related to specific gravity within a tree and between trees should indicate these criteria. Of possible significance are the following properties:

Pentosans

Within a tree, pentosans content increases as specific gravity decreases, but no such relationship characterizes between-tree variations in specific gravity. Pentosans variations noted in the wood are also noted in the pulp made from the wood. Pentosans are generally considered to contribute to paper strength, and the higher pentosans content of the tree tops is probably a factor in the higher strength (burst) of pulp from this part of the tree.

Alpha-Cellulose Content

No relationship between alpha-cellulose and wood density between trees is indicated, but within a tree alpha-cellulose decreases from butt to top. This decrease appears to be independent of the pentosans increase, since no general relationship between pentosans and alpha-cellulose contents is noted in the data of Table V, previously discussed. Other factors being equal, lower bursting strength and higher tear resistance are to be expected from higher alpha-content pulps due to less interfiber bonding resulting from reduced swellability in water. Thus, lower alpha-cellulose content is probably another factor contributing to the higher burst and lower tear of tree tops.

Cell Cross-Sectional Dimensions and Springwood-Summerwood Ratio

These two factors are considered together since they afford a picture of the distribution of cells of various sizes in the pulp. Considering that within-tree variations in cross-sectional dimensions of springwood and summerwood considered separately are minor compared to between-tree variations while the converse is true of variations is springwood-summerwood ratio, it would appear that springwood-summerwood ratio is of greater significance with respect to paper strength. This seems reasonable in view of the vastly greater differences between the dimensions of springwood cells and summerwood cells in a given tree compared to differences in the dimensions of either springwood cells or summerwood cells between trees.

Table VI. Fiber Characteristics

Tree	Position	Chip specific gravity	Clark classification: % Retained on screen mesh 14	30	50	100	Average fiber length,[a] mm.	Microscopic fiber length, mm. (number average)	Springwood-summerwood ratio (% of total fibers)
L	Bottom	0.505	53.5	32.3	7.7	2.5	3.05	2.26	37/63
L	Middle	0.466	61.5	24.7	6.8	2.9	3.16	2.61	56/44
L	Top	0.415	53.7	29.4	8.1	3.4	3.00	2.36	65/35
A	Bottom	0.603	51.4	31.4	8.5	2.8	2.97	2.37	45/55
A	Middle	0.571	58.9	25.2	7.9	3.2	3.08	2.34	51/49
A	Top	0.538	56.3	27.8	8.2	3.6	3.06	2.34	57/43
H	Bottom	0.653	53.7	32.5	7.3	2.2	3.06	2.51	41/59
H	Middle	0.610	53.7	28.6	8.3	3.6	2.98	2.23	53/47
H	Top	0.549	53.3	29.9	8.4	3.6	3.00	2.29	57/43

[a] Clark factors for pine:
14 mesh—3.8 mm.
30 mesh—2.7 mm.
50 mesh—1.7 mm.
100 mesh—0.9 mm.

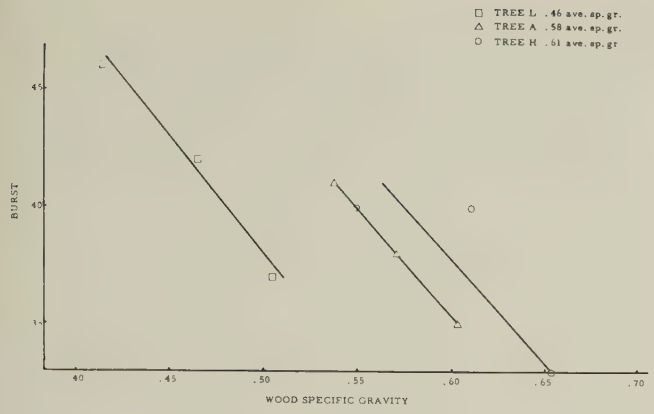

Fig. 2. Wood density versus bursting strength

Noble & Wood Beater—650 ml. Canadian standard freeness

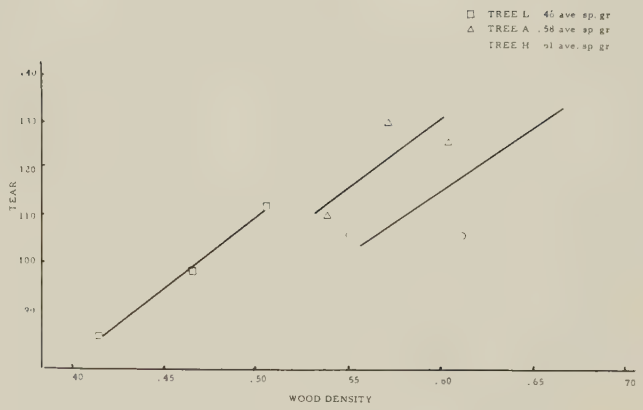

Fig. 3. Wood density versus tear resistance

Noble & Wood Beater—650 ml.—Canadian standard freeness

CONCLUSIONS

From the paper strength data given one would conclude that either high or low density wood could be considered desirable depending on whether or not high tear or high bursting strength is desired. Based on present knowledge this is true, but high tear and high burst need not be incompatible. As previously pointed out, the greater change in paper strength with specific gravity within a tree suggests that other wood characteristics varying with specific gravity within a tree (but not between trees) influence paper strength. One might reason then that both high tear and high burst could be obtained from wood having high density, high springwood percentage, high pentosans content, and low alpha-cellulose content. The extent to which each of these characteristics influences paper strength needs to be determined by further work.

Based on present knowledge, it is concluded that specific gravity should be considered a factor in plus tree selection only to the extent that it influences wood (and pulp) yield. Additional studies may lead to a combining of specific gravity, springwood percentage, pentosans content, and alpha-cellulose (and possibly other factors such as fiber strength) into a pulp quality term which can be evaluated in judging tree superiority.

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Evaluating Industrial Adhesives

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Recent critical laboratory examination of the rheological behavior of certain industrial adhesives has led to a close correlation with machine performance. Measurements made under conditions simulating actual use take nearly all of the uncertainty out of conventional adhesive testing procedures. Although much still remains to be learned, a good start has been made toward eliminating the "art" of adhesive testing. This paper describes a simple viscometer that has been found useful in predicting adhesive behavior in a paper converting operation.

The study discussed is by no means complete as the authors' understanding of the rheological behavior of industrial adhesives is limited and perhaps the presentation is somewhat premature. The discussion is limited to the study of polyvinyl acetate emulsion adhesives, and their industrial application to the high speed gluing of paper surfaces.

It is a known fact that for a given adhesive, thicker films produce slower or longer setting speeds (Fig. 1). Consideration of this qualitative fact led us to investigate its quantitative aspects, and it soon became apparent that for the industrial applications we had in mind, the importance of wet film thickness could not be dismissed lightly (Fig. 2). Controlling wet film thickness then becomes a necessary part of any adhesive application technique where setting speed is a factor.

Several laboratory techniques for casting films of various thicknesses were evaluated. During this evaluation, consideration was given to the effect of paper surface, adhesive solids, and the viscosity of the adhesive. Surface characteristics of the paper proved to react much as expected—the smoother the surface, the thinner the film thickness of a given adhesive by a given application technique (Fig. 3). However, when different adhesives of the same solids content and the same Brookfield viscosity were evaluated on the same paper, results often did not follow our theoretical pattern. Film thicknesses varied even though all conditions apparently were held constant. It was evident that we were not measuring something correctly (Fig. 4).

An attempt to introduce a new adhesive to the production operation failed despite the fact that laboratory evaluation had shown the new and old materials to be

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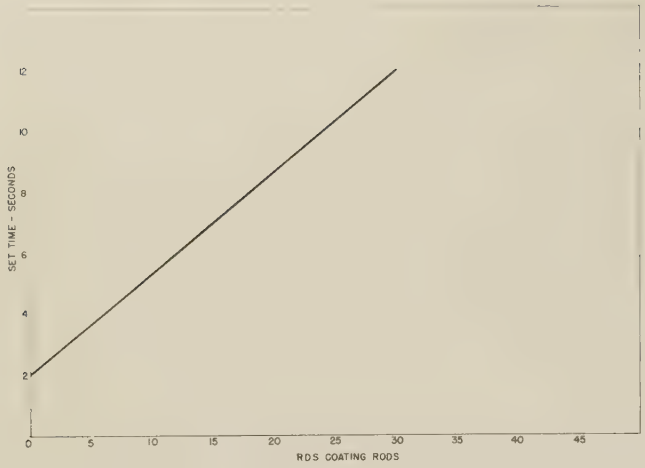

Fig. 1. Film thickness versus setting time

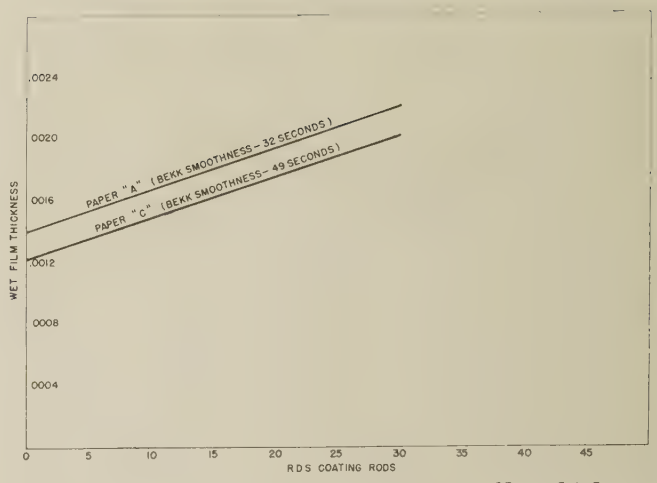

Fig. 3. Relations of paper finish to wet film thickness

almost identical. This confirmed that something was missing in our laboratory technique.

Close observation of this production trial revealed that where one adhesive worked satisfactorily, the other produced dry bonds on the same machine at the same operating conditions. The phenomenon of dry bonds indicated a thinner adhesive film, and in turn, this pointed to lower viscosity since the two adhesives contained the same total solids. Despite the fact that the viscosity of the two adhesives was identical as measured with the Brookfield instrument, we suspected that the key to our problem lay in this characteristic of the adhesive. We decided to attempt to simulate machine conditions more closely when measuring viscosity, and soon learned that the shearing rates involved were far higher than had been imagined, and certainly far above the measuring techniques then being used. The problem now became how to measure viscosity at high rates of shear.

Commercial instruments designed to measure viscosity at high rates of shear were investigated and found to be wanting for various reasons—not the least of which was their high price. It appeared simpler to achieve high rates of shear at low cost by using a capillary than by other means, and so we assembled the first instrument from parts available in the laboratory. Although crude, the initial experiments proved fruitful, and encouraged us to do more work. After making a comprehensive literature study, we elected to stay with the capillary type, and rebuilt the instrument to its present state (Fig. 5).

Basically, the instrument consists of four sections—the pressure control section, storage section, flow control section, and capillary.

The pressure section consists of a 300 p.s.i. air supply which is filtered through a stone type filter and is regulated by a 0 to 300-lb. regulator. Pressures are read from a 0 to 30-lb. or a 0 to 300-lb. precision calibrated gage according to the pressure range being used. The 0 to 30-lb. gage is subdivided in 0.1-lb. units while the 0 to 300-lb. gage is subdivided into 1.0-lb. units.

The storage section consists of a 10 in. long section of 2 in. diam. sanitary stainless steel tubing. The capacity of this fluid reservoir is 400 cc. Special metal reinforced plastic tubing connects the storage chamber to the flow control section through snap-on fittings.

The flow control section is composed of a fluid chamber, inside of which is the fluid valving system operated by a bellows air valve. This portion is specially designed. The capillary section is attached to this by carefully machined threads and is manufactured from seamless stainless steel tubing. The entrance to the capillary is square in cross section and polished to a high finish to avoid entrance disturbances.

Cleaning the instrument is facilitated by having hot and cold water lines connected to the fluid reservoir by a valve. After a run, water is turned on and flushes the whole area previously covered by a test liquid. Ease of disassemblage further facilitates cleaning.

Although we would like to make further improve-

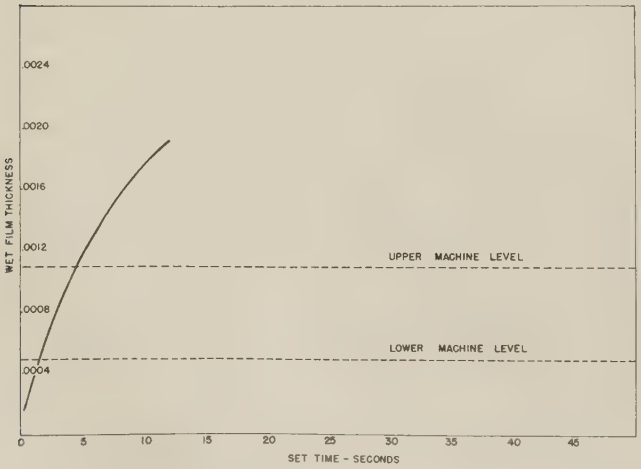

Fig. 2. Wet film thickness versus setting time

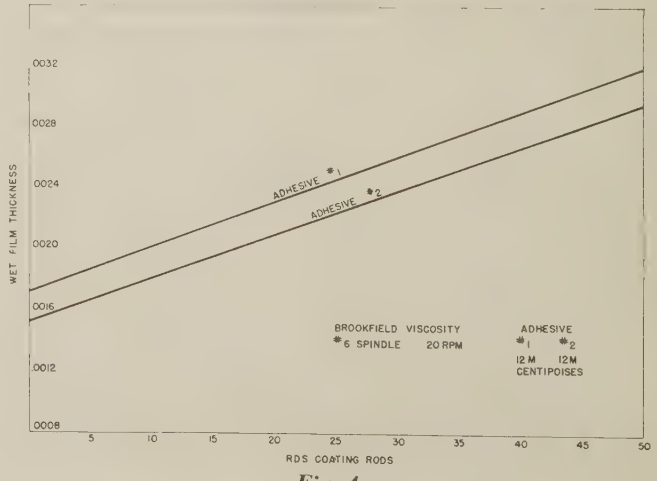

Fig. 4

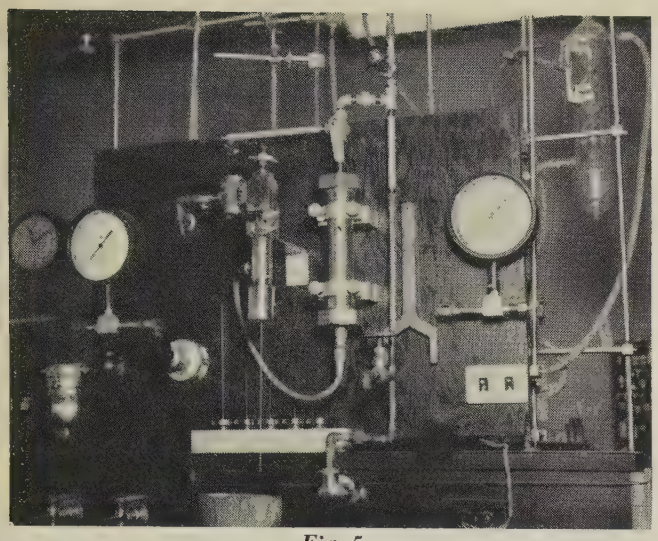

Fig. 5

ments in the instrument, it is very workable and has provided us with some very helpful and gratifying information. Just how good is it, what can it do, and what good is the information it produces?

First, the instrument is reliable, being able to reproduce values very closely from time to time, using the same fluid. Secondly, it has been calibrated using a series of Newtonian fluids of known viscosity. Thirdly, the measured values of thixotropic materials have been checked by other means and found to be extremely close (exact for our practical purposes). It can be used to measure apparent viscosities at shear rates up to about 300,000 sec.$^{-1}$, and this range could be extended if we rebuilt the unit to withstand higher pressure.

The instrument is easily used and cleaned, and would make a reasonably good control instrument. The value of the information it produces really is the reason for this paper. It has enabled us to predict whether or not a new adhesive will work in a given application.

Returning to the adhesive trial previously mentioned, we found that under shear, the adhesive that did not work decreased in viscosity more than the satisfactory adhesive (Fig. 6). The lower viscosity caused a thinner film to be applied, and the thinner film dried more rapidly (in this case, too fast for the operation), creating the dry bond (Fig. 7).

Such studies on the relationship of viscosity to film thickness which we have made are confirmed in the

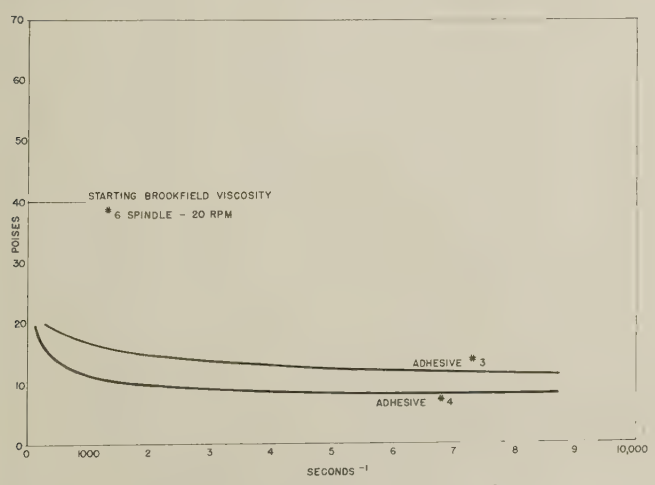

Fig. 6. Shear rate versus viscosity

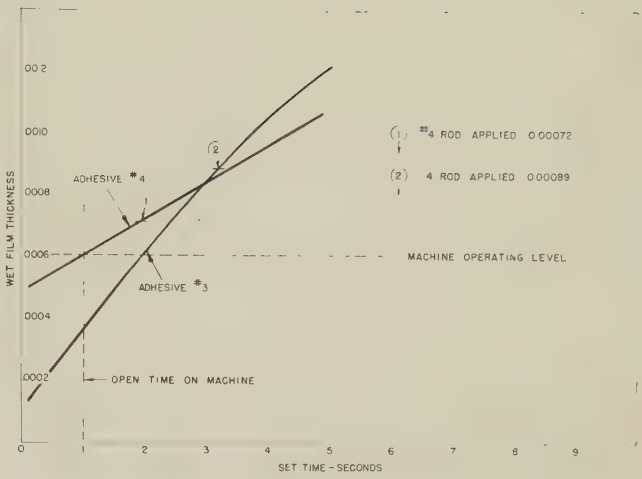

Fig. 7

literature for other end applications; they lead us to conclude that for a given application technique on any given surface, viscosity is the controlling factor over film thickness, and that the viscosity must be measured at rates of shear comparable to those used in casting the film. Returning to Fig. 6, please note that the two adhesives having the same Brookfield viscosity have entirely different viscosities at 9000 sec.$^{-1}$. It has already been shown that the film thicknesses are different under machine conditions at high rates of shear.

Another example is shown in Fig. 8 of an adhesive that according to low shear measurements is almost Newtonian but which turns out to be very thixotropic at higher rates of shear. This adhesive is also highly resistant to shear, and as a consequence, produces wet films of greater thickness when applied by the same techniques as the previous example.

Still another example (Figs. 9 and 10) shows two materials that are nearly alike in all respects including viscosity at high shear. One of these formerly was a regular production adhesive; the other was submitted as a lower cost replacement. Needless to say, we are now using the lower cost replacement with great success.

Taylor and Zettlemoyer recently published an excellent study on the mechanism of ink splitting during printing. Their paper includes a very clear description of the probable shear rate gradients through a film as it is applied to paper, and they describe the pressure gradients which exist in a liquid film during roll-plane application. The authors made certain assumptions in

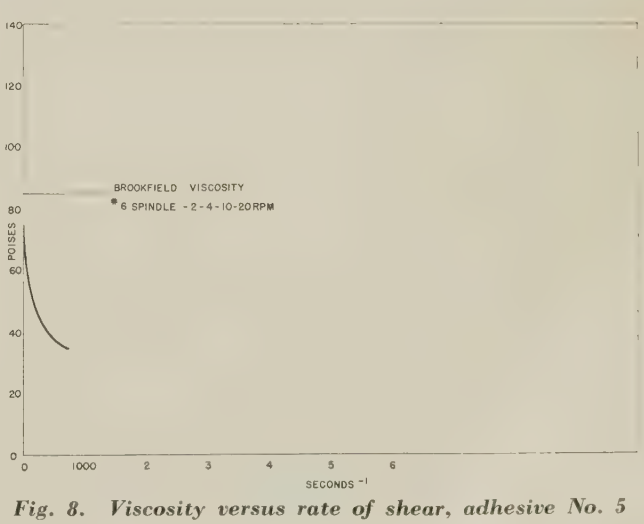

Fig. 8. Viscosity versus rate of shear, adhesive No. 5

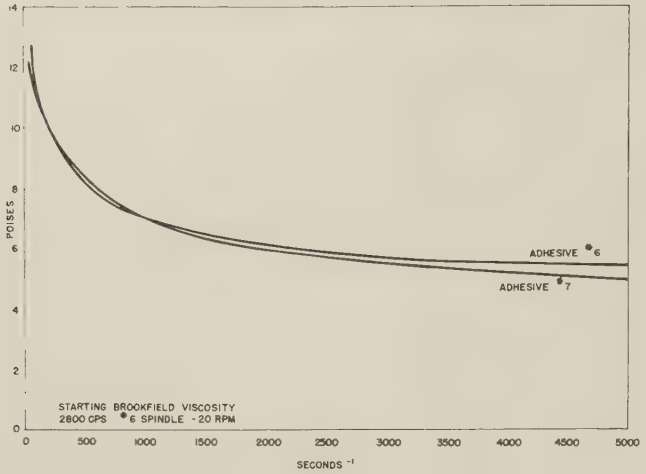

Fig. 9. Viscosity versus rate of shear, adhesive No. 6 and adhesive No. 7

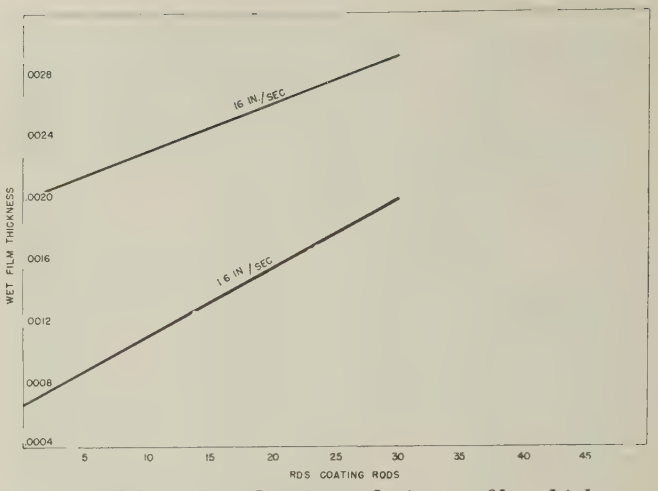

Fig. 11. Effect of application velocity on film thickness, adhesive No. 5

order to derive a mathematical relationship. For the conditions they selected, we agree that the assumptions appear valid, but there are other paper converting operations where such assumptions do not appear to hold. For such cases, a different explanation is required, although the same principles are involved. We propose that in studying the fluid mechanics of roll-plane or roll-roll nip systems found in paper converting machinery such as adhesive applicators, coating heads, size presses, doctor systems, etc., it is not valid to assume as they did that the roll(s) rotates about a fixed axis and that paper is noncompressible. In addition, we suggest that it is necessary to consider that paper is both porous and absorbent, and that the rheology of the fluid in the nip will be significantly influenced by this fact.

If one were to agree that a roll does not, in the strict sense, rotate about a fixed axis, but that in relation to the film thickness to be applied it is free to move due to machine design or simply to the clearances found in commercial bearings, then it is easy to see that the more viscous the fluid, the more the roll will "ride up" and the thicker the film that will result. To prove this, Fig. 11 shows the adhesive used in Fig. 8 applied to paper by the same technique at two different rates of application. Note the significant change in film thickness. This has been treated theoretically by Arnold and by a host of other workers. Likewise, if the compressibility of paper or board is recognized and/or the axis of the roll is restricted, an opposite result will be realized. Figure 12 shows the same adhesive applied to paper at the same linear speed, but under two conditions of pressure on the applicator.

There are indications from our set time curves that the rate of loss of vehicle (water in the case of an adhesive) into paper is extremely high. This loss of water would result in a rapid local build-up of viscosity close to the paper surface at a point where the rate of shear is high. The high viscosity and high rate of shear would lead to a rapid rise in temperature and a subsequent marked drop in local viscosity, causing the film to split at this point. This seems to us a more logical explanation than the shear effect at the nip entrance and the poor surface heat conductance of paper.

SUMMARY

We have shown that there is a direct relationship between wet film thickness of an adhesive and its setting speed. We have described an economical instrument for measuring viscosity at rates of shear comparable to those found in certain paper converting operations. By measuring viscosity at rates of shear comparable to those developed in casting the adhesive films, we have demonstrated the relationship between wet film thickness and viscosity.

We explain the effect of viscosity on film thickness in part on the pressure build-up in the fluid film which re-

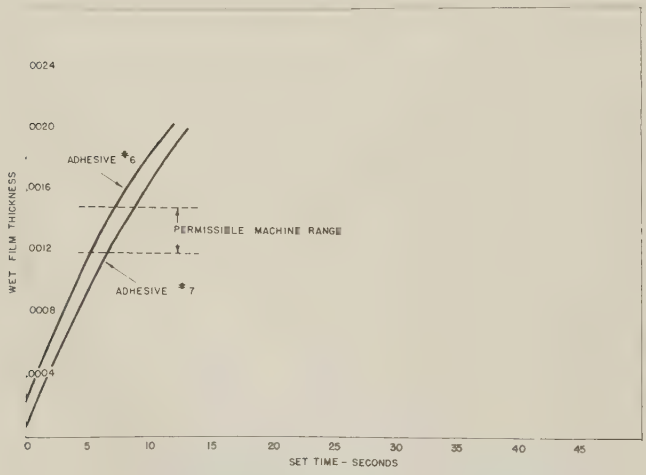

Fig. 10. Wet film thickness versus set time, adhesive No. 6 and adhesive No. 7

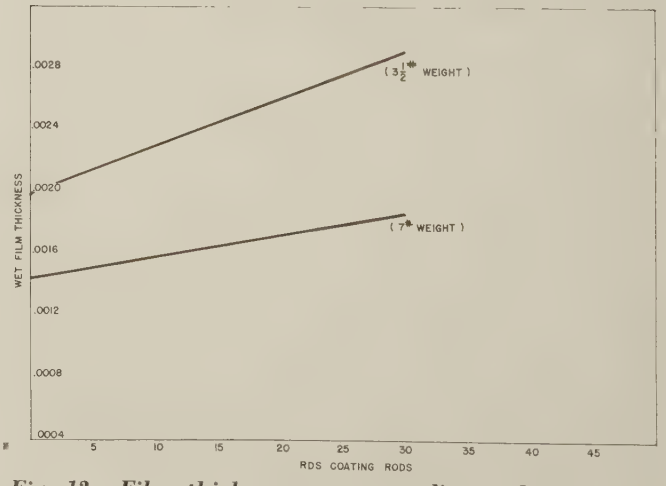

Fig. 12. Film thickness versus applicator loading, adhesive No. 5

lieves itself either by causing the applicator part to "ride up" on the viscous adhesive or by compression of the paper or both. Another part has to do with the significance of viscosity in the splitting of the film during application.

Finally, we believe that a portion of the fluid or vehicle component of the adhesive is absorbed by and/or pushed into the paper by the pressure in the nip which leaves a higher concentration of solids in the wet film immediately next to the paper surface. The higher viscosity at this point will offer greater resistance to shear than the bulk of the film. This will cause a local increase in temperature, which in turn will cause the viscosity to drop below that of the bulk of the film, and as a result, it will become the point for splitting of the film. These concepts have been applied to the laboratory evaluation of adhesives with excellent confirmation on automatic converting machinery.

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Methods Used in the Characterization and Proof of Structure of Cell-Wall Polysaccharides

ROY L. WHISTLER

This article describes new methods and their application to solve present problems concerning cell-wall polysaccharides.

Cellulose and hemicelluloses are the major carbohydrate components of plant cell-walls. The importance of cellulose need not be stressed since its usefulness is broadly recognized. Hemicelluloses assume particular significance because of their extensive occurrence as cell-wall components in all higher land plants (*Spermatophyta*). They constitute about 25% of woods and about 25 to 40% of agricultural crop residues, such as wheat straw, corn stalks, cobs, and soybean hulls. The chemical and physical nature of these various polysaccharides is important, therefore, not only because of interest in their fundamental chemistry but because they are in such great abundance that in the future they will become of industrial use, perhaps the basis of new industries.

Methods for the characterization and proof of structure of hemicelluloses and other cell-wall polysaccharides are important, but are mainly the same methods by which polysaccharides may be characterized.

In general, methods used in the characterization of polysaccharides may be divided into five groups; (I) methods used to determine the characteristics of a polysaccharide as it occurs in its natural biological state within plant tissue, (II) methods used to isolate a polysaccharide in pure and undegraded condition, (III) physical methods used to characterize the pure polysaccharide including the determination of molecular weight and molecular shape, (IV) chemical methods used to characterize the polysaccharide and especially to elucidate structure, and, (V) methods used to characterize a polysaccharide for potential industrial uses. Group V includes some of the methods of Group III and IV but encompasses other procedures associated more often with practical science.

Recent developments in these various areas can be reviewed in part by describing how they have advanced present knowledge. Since proper review of the many developments cannot be given here, only a few will be mentioned in Groups I to IV. Of the various categories least progress has been made in Group I and it is here that new methods are most needed.

I. METHODS FOR CHARACTERIZATION OF POLYSACCHARIDES WITHIN PLANT TISSUE

Many workers have attempted to answer the question of whether plant cell-wall components are covalently linked, in part, with one another. The origin of the problem is the need to explain the differences in solubility of some cell-wall polymers before and after isolation. Low solubility of the polymers while in the cell-wall is ascribed by many workers to covalent bonds. Other investigators believe the low solubility of certain cell-wall polysaccharides results both from the numerous secondary forces which hold the molecules to other components and from their entrapment with other types of molecules with which they are entangled and overlayed.

Evidence which suggests entangling would include the observation that as the cell-wall is ground the finer particle sizes yield proportionally more extractable hemicellulose (*1*). Furthermore, extractability of hemicelluloses decreases under conditions which swell cellulose. However, accumulated evidence points to at least a chemical combination between lignin and hemicellulose (*2*). A lignin-carbohydrate complex is extractable with dimethylformamide from finely milled wood. A lignin-xylose compound is extractable from acetylated beech wood (*3*); and strong evidence for a phenol-xylosidic bond in wheat straw results from ultraviolet absorption measurements and from limited chemical data (*4*). Ultimate proof of the occurrence or nonoccurrence of covalent crosslinks between cell-wall polysaccharides, or polysaccharides and lignins, may not be obtained for some time because of the great difficulty in proper characterization of a polymer both before and after its removal from its natural matrix, and because of the difficulty in clearly distinguishing whether covalent bonds are broken under extractive

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conditions. While evidence seems to indicate that most cell-wall polysaccharides are in physical admixture only, some covalent crossbonding must surely exist. If not formed enzymatically during the development of the cell-wall, the energetics, hydrogen ion concentration and concentration of reactants in cell formation are such that some few purely chemical reactions could occur. Limited chemical synthesis of linkages seems entirely reasonable.

This purely chemical formation of bonds also seems to be one reasonable explanation for the unusual glycosidic bonds found in many polysaccharides. During the past few years much has been heard of the so-called "anomalous" linkage found in such otherwise uniformly linked polysaccharides as cellulose, xylan, and starch amylose. The occurrence of an odd or unusual glycosidic bond among hundreds of uniform linkages seems to be fully expected and reasonable. It might arise from a momentary aberration in the catalytic activity of the normal synthesizing enzyme, which is caused by a variation in solution kinetics or concentrations in the plant cell; or it might arise from the intrusive action of another enzyme. If, however, enzymes are above reproach, there is the entirely reasonable possibility of linkage formation from a purely chemical reaction.

Another problem has been a concern about the physiological role of cell-wall components. Although cellulose is regarded as a structural polysaccharide with no food-reserve function, there is less agreement concerning the function of the hemicelluloses. Schulze, who coined the term hemicellulose in 1891, considered them as food reserves and much of the first work with woody plants was interpreted as evidence that the hemicelluloses were reserve polysaccharides. In fact, one finds the term "reserve hemicellulose" in early books on plant physiology.

Murneek (*5*) believed that hemicelluloses were food reserves in apples. However, investigations with grape stems by Winkler and Williams (*6*) failed to show indication of metabolic utilization of hemicelluloses. These workers reviewed earlier literature and pointed out the lack of definite evidence to support the assumption that hemicelluloses function as reserve food.

Investigations disclosed no turnover of hemicelluloses in the vegetative parts of subterranean clover plants(*7*).

Biosynthesis of xylan has been studied by Neish (*8*) and Altermott (*9*) using C^{14}-specifically labeled sugars. They suggest that uridine diphosphate glucose is the central metabolite of the synthesis of cell-wall polysaccharides and that glucose may undergo isomerization, oxidation, and decarboxylation to give rise to the different sugar residues found in these polysaccharides. Evidence that xylan is more readily reabsorbed in the cell-wall and recycled than is cellulose was obtained in a 24-hr. experiment.

At Purdue, actively growing oat plants permitted to photosynthesize $C^{14}O_2$ for 3 hr. were sampled at about 5 to 8-day intervals until maturity. The total activity of the hemicelluloses increased during the first 5 days, after which time it remained constant indicating definitely that the hemicelluloses are not further metabolized and are hence physiologically inactive cell-wall ingredients (*10*).

Electron microscopy is providing much exact information on the natural relationship between cell-wall components.

II. METHODS FOR ISOLATION AND PURIFICATION OF POLYSACCHARIDES

A major problem prevalent in the examination of cell-wall polysaccharides is the difficulty inherent in obtaining a pure polysaccharide that may be subjected to an unequivocal structural investigation. Separation of polysaccharides from plant material and from each other is tedious and requires the exercise of utmost judgment and technical ability if pure polysaccharide is to be obtained in a natural and undegraded condition.

So far, alkaline extraction of holocellulose has proved useful as a means for the isolation of a group of polymers which can later be separated. The oxidative action of chlorite is minimal and this reagent has been widely used to delignify plant material. Alkaline extraction of the holocellulose can, however, bring about many changes in the polysaccharide. The destruction occurring in the presence of oxygen is well known. But even under oxygen-free conditions alkaline degradation might result. The degradation of polysaccharides in alkalies has been investigated extensively (*11*) by the research group at the British Rayon Research Association and later at Purdue. Fortunately, perhaps, when chlorite is used to produce holocellulose a rather specific oxidation transforms the reducing end of the polysaccharide chains to glyconic acid residues. This change stabilizes some molecules to the purely alkaline degradation which must begin at a reducing end group (*12*). Stabilization of the aldehydic chain ends by glycosidation (*13*) or by reduction to alcohols (*14*) is also possible. Alkaline degradation could still occur in those hemicellulose molecules which contain carbonyl or carboxyl groups on nonterminal sugar units. Another type of degradation which may occur especially with hot alkaline solutions is transglycosidation. For example, under pulping conditions xylans are broken with chain transfer to cellulose and perhaps to other molecules (*15*).

Solutions of potassium hydroxide have been extensively used to extract hemicelluloses from various pulps including holocellulose. One advantage is that on neutralization of the extract with acetic acid, the potassium acetate formed has good solubility in ethanol and may be removed thereby. Schoettler (*16*) has found potassium hydroxide solutions better extractants for aspen wood xylan than are sodium hydroxide solutions. However, sodium and lithium hydroxide solutions are more effective than potassium hydroxide solution for dissolving glucomannans from western hemlock holocellulose (*17*).

Possibly one of the great disadvantages in alkaline extraction of hemicelluloses is that any naturally occurring ester groups are saponified. Jones and Wise (*18*) suggested that acetyl groups were present in wood hemicelluloses and were probably attached to D-xylose units. Using dimethylsulfoxide (*19*) as an extractant of birch holocellulose a glucuronoxylan with 17% acetyl has been isolated (*20*).

Still the most difficult problem in hemicellulose chemistry is that of the effective isolation of a chemically homogeneous polysaccharide. All known methods of polymer separation have been applied to the hemicelluloses but without general success. Electro-

phoresis (*21–26*) is one way of testing chemical homogeneity of polysaccharide materials. While not applicable to macroseparations, a small scale preparation column has been developed (*27, 28*).

Most attempts to fractionate hemicelluloses make use of precipitation. Numerous investigators have complexed polysaccharides with copper salts. Fehling's solution (*29–34*) is often used, while solutions of cuprietylenediamine (*35*), cupric chloride (*36*), cupric sulfate (*37*), and cupric acetate (*38, 39*) have also been employed. In most instances the copper complex which precipitates is removed by filtration or centrifugation and decomposed by an ethanolic solution of acid or by a chelating agent; the polysaccharide is then washed free of inorganic ions. Alkaline iron tartrate has been used similarly to precipitate soluble hemicelluloses (*40*).

An interesting precipitant for polysaccharides which has been investigated at Birmingham is cetyltrimethylammonium bromide (*41–44A*). When added to a neutral mixture of acidic and neutral polysaccharides it will precipitate the acidic ones as insoluble quaternary ammonium salts. Neutral polysaccharides which have been complexed with borate will precipitate in the same manner (*45*). At Purdue cetyltrimethylammonium bromide has been used successfully to separate hemicellulose from corn stalk (*46*).

A purification procedure found satisfactory in many applications is the fractional precipitation of dilute polysaccharide solutions by the gradual addition of ethanol. There are many examples of this fractionation method. In one instance, a mixture of acidic hemicelluloses from corn cob at 2% concentration and at pH 2 was separated into numerous fractions by repeated additions of ethanol to succeeding points of incipient turbidity, and individual fractions were removed by centrifugation. In this way the fractionation curve shown in Fig. 1 was obtained. While pH 2 is recommended for analytical observation, it is obviously too acidic for preparative separations (*47*) in which a neutral pH should be used to prevent hydrolysis (Fig. 2).

Zone electrophoresis (*48*) and other electrophoretic separations are showing considerable usefulness.

III. PHYSICAL METHODS FOR CHARACTERIZATION OF POLYSACCHARIDES

Primary methods for the determination of molecular weights of macromolecules continue to remain in wide use in polysaccharide research. The most widely used methods, osmotic pressure, ultracentrifugation and light scattering, are continually undergoing improvement. The useful Zimm-Myerson osmometer (*49*) was improved by various workers, especially Stabin and Immergut (*50*) and Riesel and Berger (*51*). Because historic solvents for cellulose may lead to oxidative and alkaline degradation, cellulose is frequently measured as the acetate or nitrate in organic solvents. Of these three molecular weight methods, light scattering gives more information about the shape of molecules in solution. Foster (*52*) has examined the shape of amylose in dimethylsulfoxide, aqueous potassium chloride, and aqueous potassium hydroxide, and related the data to limiting viscosity numbers. The amylose molecules appear to be in a coiled conformation. Isothermal distillation, often satisfactory in the molecular weight range 3000 to 20,000, has been applied by Aspinall (*53, 54*) to hemicelluloses in this weight category.

Infrared radiation, long a tool of importance when used with simple molecules, has been found very useful with polysaccharides. Absorption spectra can provide strong evidence of α or β configurations of the anomeric carbon atom of glucans (*55*). Both the accessibility and crystallinity of a cellulose were determined by Mann and Marrinan (*56*) through comparison of the absorption spectra of cellulose before and after exposure to deuterium oxide. The data also offer further support to the belief that water does not penetrate the crystalline regions. The use of polarized infrared radiation (*56–58*) has given much insight to the nature of hydrogen bonding in the crystalline regions of cellulose I (native cellulose).

The problem of the weak link, or, more properly, the acid-sensitive link, of polysaccharides, especially cellulose, has been logically resolved. Unmodified cotton contains very few, if any, acid-sensitive linkages, but such linkages may be readily introduced by small amounts of oxidation under alkaline conditions (*59*).

IV. CHEMICAL METHODS FOR DETERMINATION OF STRUCTURE

Much structural information on different polysaccharides is still obtained by the excellent classical methods so well known to polysaccharide chemists. Since 1950, the method of fragmentation analysis has come into general use for establishment of the glycosidic linkage between chain units. If enough oligosaccharide units are obtained, it is possible, by this method, to fit these isolated jigsaw puzzle pieces together and obtain a structural picture of the original polysaccharide. The fragmentation method evolved because oligosaccharides became separable by chromatography.

Carbon-celite columns (*60*) handle large quantities and permit the separation from each other of oligosaccharides at different degrees of polymerization. Addition of borates and molybdates (*61*) permits separation of oligosaccharides of the same degree of polymerization. Cellulose columns allow excellent separation of individual oligosaccharides although the columns do not have large capacities per unit of cellulose (*62*). Polysaccharides are usually fragmented by graded acid hydrolysis but enzymic hydrolysis has become common. Painter suggests enzymic fragmentation in a dialysis bag so that oligosaccharides are removed before they can undergo further degradation (*63*). By either acid or enzymic hydrolysis the investigator must be watchful for the appearance of synthetic oligosaccharides. Aldobiouronic acid fragments are ordinarily separated as their calcium salts and purified by separation as free acid by paper chromatography with acidic irrigants or by gradient acid elusion from weak anion exchange columns.

Alkaline degradation of carbohydrates, so long explored by competent investigators, can provide information on polysaccharide structure. The mechanism of the reaction is now clear and is based on the electronic exposition of Isbell (*64*) who presented a modern version of Nef's (*65*) proposal. These basic concepts have been extended and amplified by Kenner, Corbett, Richards, and others (*11*). Providing the polysaccharide has a reducing end group and 1—3

or 1—4 glycosidic linkages in the main chain, the alkaline degradation can proceed stepwise to provide sequentially saccharinic units. Whistler and Corbett (*12*) suggest the use of alkaline degradation for determination of branching in polysaccharides and substantiation of the method is obtained by successful application to guaran (*66*).

New methods continually arise for determination of carbonyl groups of polysaccharides. One of the most widely used is the hydroxylamine method of Purves (*67*). However, the reduction of the carbonyl group with borohydride as suggested by Lindberg and Theander (*68*) seems to be quite applicable and will undoubtedly receive extensive use. Reducing end groups can be measured readily by improvement in the sensitivity of the method using 3,5-dinitrosalicylic acid (*69*).

Periodate ion can be used to establish the presence of glycose units in a polysaccharide which are the sites of several branches, since these glycose units of the polysaccharide will be unattacked following the oxidation. Using the sequence of reactions employed by Jayme (*70*), Smith and co-workers (*71*) treated polysaccharides with periodate and then reduced to obtain the polyalcohol. These reduced derivatives can be hydrolyzed without excessive degradation and allow the isolation of the unattacked units as the corresponding glycitols. The method seems widely applicable.

Use of antisera for analysis has been explored by Heidelberger (*72*) and it is likely this analytical procedure will find much wider application in the future.

This has been a very limited presentation of some of the present concepts and some of the recent methods which are now advancing the knowledge of polysaccharide chemistry. As new methods continually evolve and are placed in the hands of scientific workers we may expect an even more rapid exposition of the fine structure of both the plant and animal polysaccharides.

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Concora Instrumentation Studies

I. The Concora Torsion Tear Test

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The purpose of this paper is to report our studies on the development of a new method for measuring tear on linerboard grades, called Concora torsion tear. This method is more meaningful and more precise than Elmendorf tear, the standard method now in use. Other uses of Concora torsion tear which add to its versatility have already been described (*1*).

The need for a better method of evaluating tear stems from the disadvantages of the present method:

1. Present tear tests are made on specimen which are precut with a blade, and the result obtained reflects the energy necessary to *continue* the tear on this precut sample. What is actually wanted and of greater interest and importance is the energy required to produce the *initial* tear, in the absence of any prior cut or tear existing on the sheet. This property is not measured by the present method.

2. The Elmendorf tear test produces "diagonal tears," an effect particularly pronounced in the "across" direction, i.e., starting from the precut incision, the tear produced is a meandering or diagonal one, instead of being straight. According to the test procedure, the operator is permitted to discard such values.* Any test procedure which allows an operator to accept or reject test results is technically questionable, because it permits the introduction of bias.

The Concora torsion tear test was developed to eliminate these disadvantages:

1. The tearing action on this tester is a twisting or torsion motion, corresponding to the way tears are produced in actual practice.

2. The tear produced is an initial tear on an uncut specimen.

3. Cross-machine direction tears are straight, removing the necessity for the operator to decide when to include or exclude the test value. The result is unaffected by the location of the tear between the two jaws.

4. Since all tests are accepted and none rejected or discarded, Concora torsion tear testing results in an economy of testing effort.

5. In addition to these advantages, Concora torsion tear is part of a "test system" which, in conjunction with the Concora boxboard scorer and the Concora folder gluer, permits the evaluation of adhesives, and the surface and adhesion characteristics of liners and folding boxboards, described in (*1*).

CONCLUSIONS

Table I shows the relationship of total tests run to acceptable tests obtained on both Elmendorf and Concora torsion tear, for various liner grades tested in both the machine and across directions.

Table I. Number of Tear Tests Run Versus Number of Acceptable Tears[a]

Liner grades	*Elmendorf tear*		*Concora torsion tear*	
	O.D.	*M.D.*	*O.D.*	*M.D.*
26-lb. kraft	100 (81)	100 (100)	100 (100)	100 (100)
38-lb.	100 (61)	100 (99)	100 (100)	100 (100)
42-lb.	100 (70)	100 (98)	100 (100)	100 (100)
69-lb.	100 (4)	100 (80)	100 (100)	100 (100)
90-lb.	100 (0)	100 (94)	100 (100)	100 (100)
Subtotal	500 (216)	500 (471)	500 (500)	500 (500)
38-lb. cyl.	100 (1)	100 (100)	100 (100)	100 (100)
44–46 lb.	100 (10)	100 (100)	100 (100)	100 (100)
50–52 lb.	100 (23)	100 (100)	100 (100)	100 (100)
75–78 lb.	100 (18)	100 (100)	100 (100)	100 (100)
103–110 lb.	100 (1)	100 (100)	100 (100)	100 (100)
Subtotal	500 (53)	500 (500)	500 (500)	500 (500)
Grand total	1000 (269)	1000 (971)	1000 (1000)	1000 (1000)

[a] Acceptable means no diagonal tears.

The Table shows that:

(a) Diagonal tears occur primarily in the "across" direction but on the heavier kraft grades there is some tendency to find this effect in the machine direction also.

(b) The loss in testing effort represented by the discarded diagonal tears varies with the grade tested. On 69 and 90-lb. kraft, and almost all of the cylinder liner grades this loss is so great that diagonal tears almost have to be accepted. For the most common liner grade in use, 42-lb kraft, this loss in testing effort for o.d. tears was 30%, 100 tests produced only 70 acceptable results. To put this differently, in order to get 10 good tears, one has to run approximately 14 tests.

2. Five operators tested 20 samples/grade/test direction, designating what they would consider diagonal tears. These operators had varying degrees of test experience as follows:

(a) Operator no. 1 is a supervisor who knows the test procedure but ordinarily does no testing himself.

(b) Operator no. 2 is a new laboratory technician who was taught the method and then was asked to run these tests, the first he had ever done.

(c) Operator no. 3 is an instrumentation engineer who calibrates test equipment and checks them by actual tests, i.e., he has considerable experience.

(d) Operators nos. 4 and 5 are laboratory tech-

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* T 414 m-49 states: "For accurate results reject readings obtained where the tear deviates more than 10 mm. (3/8 in.) away from the line of initial slit. When it is necessary to include such readings, a notation should be made and the deviation given." Note that the procedure recognizes situations where no tests can be rejected and all must be used, for example, if there are too few samples, or on some grades where diagonal tears always occur. This is a highly unsatisfactory situation.

Table II. Discarded Diagonal Elmendorf Tears for Five Operators (Nos. 1–5)

All operators ran 20 tests/grade/test direction

Liner grade	OD tears No. 1	OD tears No. 2	OD tears No. 3	OD tears No. 4	OD tears No. 5	MD tears No. 1	MD tears No. 2	MD tears No. 3	MD tears No. 4	MD tears No. 5
26-lb. kraft	8	5	0	2	4	0	0	0	0	0
38-lb.	8	7	13	5	6	1	0	0	0	0
42-lb.	9	8	7	4	2	2	0	0	0	0
69-lb.	18	20	18	20	20	4	5	5	2	4
90-lb.	20	20	20	20	20	3	2	1	0	0
38-lb. cyl.	19	20	20	20	20	0	0	0	0	0
44–46-lb.	15	19	17	19	20	0	0	0	0	0
50–52-lb.	18	14	6	19	20	0	0	0	0	0
75–78-lb.	20	10	12	20	20	0	0	0	0	0
103–110-lb.	20	20	20	19	20	0	0	0	0	0

nicians with many years of experience whose regular duties include the running of this test.

Table II compares the judgment of these five operators on identical sets of liners with respect to the frequency of occurrence of diagonal tear. Even allowing for the random distribution of diagonal tears where their probability of occurrence is between zero and 100%, there are differences even among experienced operators.

3. The problem of evaluating data becomes very difficult when one must decide whether two sets of test results differ significantly or only due to chance variation. Table III, showing some o.d. tear test averages obtained on statistically identical sets by the five operators illustrates this.

Suppose the reader discards the diagonal tears *without* bothering to compare averages with these included, i.e., looking at the second set of averages *only*, how could one decide the following questions:

(a) On 26-lb kraft, is the high result obtained by operator 3 due to the fact that he discarded no values? The answer in this case is obviously "no," but if only operators 1 and 3 compared notes on averages with diagonal tears excluded, one could not answer this question.

(b) On the 42-lb. kraft set operators 4 and 5 obtained appreciably lower averages than operators 1, 2, and 3. In the absence of the averages with *all* values included, how could one decide that it was the paper, the operator, or the method of discarding diagonal tears which might account for this difference?

Table III. O.D. Elmendorf Tear Test Averages With and Without Diagonal Tears

Grade	Operators 1	2	3	4	5
26-lb. kraft	212	208	225	202	211
	216 (8)	207 (5)	225 (0)	203 (2)	211 (4)
38-lb. kraft	329	330	337	318	326
	328 (8)	336 (7)	338 (13)	316 (5)	330 (6)
42-lb. kraft	371	374 –	384	353	348
	371 (9)	380 (8)	385 (7)	349 (4)	349 (2)

(c) The Table also shows that there is no association between the occurrence of diagonal tears and the test level, i.e., the discarded values can be higher, lower, or equal to those which are accepted.

In other words, the problem of scatter in test data is sufficiently troublesome under the most favorable circumstances, without adding additional elements of uncertainty to complicate matters still further.

DISCUSSION

1. The data in this experiment consists of the following:

(a) 343 sets of kraft liner grades from 26 to 90 lb./MSF.
(b) 145 sets of cylinder liner grades from 38 to 110 lb./MSF.

On these sets (a) and (b), Elmendorf tear data are on a "screened basis," i.e., in accordance with TAPPI Standard 414 m-49 and ASTM (D 689–44), all diagonal tears were eliminated. Table IV shows typical Concora torsion tear values compared to Elmendorf tear for the entire range of liner grades in common use in the industry today.

(c) 5 sets of kraft liner grades from 26 to 90 lb./MSF, 20 tests/set and
(d) 5 sets of cyl. liner grades from 38 to 110 lb./MSF, 20 tests/set

were tested, each of five operators testing one set of each grade and recording all results, marking those with diagonal tears which would ordinarily be discarded.

2. A picture of the Concora torsion tear tester is shown in Fig. 1. The unit has a gage with 300 divisions which corresponds to 30 lb. We report our results in gage readings because this is the most convenient way, but if desired these may be converted to pounds by dividing by 10.

3. The Concora torsion tear tester is manufactured by Liberty Engineering Co., Beloit, Wis. Container Corporation retains all rights to this tester, and permission to purchase it may be secured by writing to F. D. Long, research director, Container Division Laboratory, Container Corp. of America, 10 North Clark St., Chicago 2, Ill.

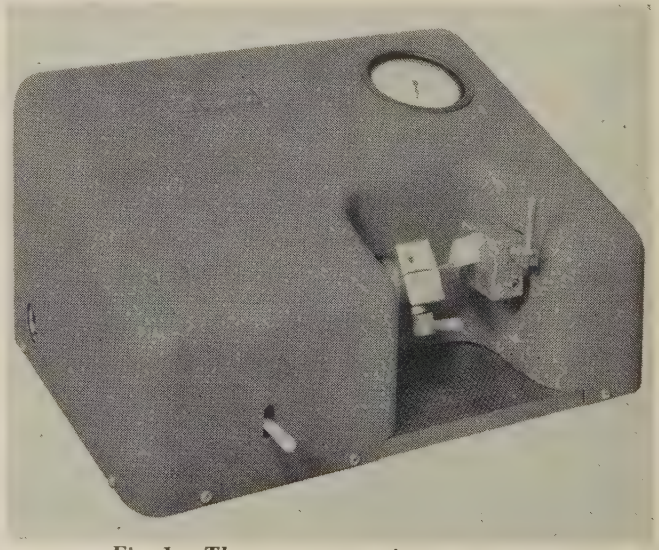

Fig. 1. The concora torsion tear tester

Table IV. Typical Average Concora Torsion Tear Values on a Variety of Liner Grades

n = 5 tests/average

Liners → No.	Machine direction — Concora, units	Machine direction — Elmendorf, grams	Across direction — Concora, units	Across direction — Elmendorf, grams
1	26	160	89	262
2	31	147	94	275
3	27	214	48	246
4	41	182	50	182
5	38	232	72	312
6	39	166	50	189
7	38	260	39	243
8	35	170	37	192
9	27	166	97	256
10	26	166	88	317
11	29	160	85	275
12	27	157	87	294
13	28	170	85	275
14	26	182	86	320
15	26	144	74	278
16	28	192	107	317
17	35	198	105	381
18	31	176	108	326
19	29	176	99	333
20	31	157	87	275
21	41	240	60	275
22	40	224	61	269
23	48	214	63	272
24	38	288	61	307
25	38	198	66	253
26	51	202	69	266
27	36	304	54	314
28	36	182	100	346
29	37	208	76	298
30	33	189	99	333
31	32	144	96	304
32	32	186	86	355
33	27	163	86	307
34	30	192	102	326
35	31	211	116	339
36	46	230	107	437
37	62	275	159	467
38	48	282	140	454
39	63	291	141	490
40	54	307	155	426
41	60	314	142	528
42	72	358	73	330
43	49	344	73	394
44	51	253	61	275
45	54	285	80	314
46	33	240	45	253
47	66	307	73	310
48	55	272	73	316
49	50	269	77	298
50	45	243	68	349
51	76	330	87	410
52	65	320	79	336
53	59	323	85	354
54	63	323	78	368
55	58	317	83	378
56	51	384	71	410
57	60	314	87	400
58	55	314	78	371
59	56	314	86	394
60	72	266	77	266
61	57	326	82	365
62	56	294	80	362
63	59	298	80	349
64	58	304	82	394
65	45	342	76	416
66	60	259	88	333
67	61	410	97	448
68	60	320	95	426
69	65	320	80	422
70	98	544	170	851
71	106	566	97	698
72	102	531	121	554
73	88	493	106	576
74	89	640	126	694
75	118	499	124	550
76	110	522	122	637
77	96	454	104	525
78	117	531	120	608
79	106	662	115	634
80	106	560	103	534
81	100	528	119	675
82	95	569	132	672
83	100	550	106	595
84	154	752	176	893
85	148	880	141	883
86	147	749	141	896
87	119	717	147	870
88	115	755	137	918
89	112	810	142	963
90	129	742	151	899
91	154	634	180	860
92	138	838	166	1050
93	131	755	174	1050
94	152	723	183	925
95	159	862	201	1171
96	152	774	169	1018
97	149	717	172	982
98	169	710	189	1002

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Received Jan. 12, 1960.

The Kohler Method of Coating

J. R. GUNNING and JOHN B. KOHLER

This is the first public disclosure of the details of construction, theory and use of the Kohler Coating Method. In this method, the paper contacts the coating color in a pond, and is smoothed and metered by a rigid blade which comprises the leaving boundary of the pond. The metering action is controlled by an air jet impinging on the back of the web, in juxtaposition to the rigid blade.

The apparatus is arranged so that the web is not deflected by either the blade or the jet, and there is therefore no component of force holding the sheet against the blade other than the force exerted by the jet.

Coating weight applied with any given formulation is controlled by varying the force of the impinging jet, and by varying the thickness of the rigid blade. There are no moving parts in the coating unit.

The paper includes a discussion of formulations which have been used for coatings applied by this method, which has a range of 2½ to 20 lb. per ream per side, over a wide range of formulation consistencies.

J. R. Gunning and John B. Kohler, Abitibi Power and Paper Co., Ltd., Control Research and Development Division, Sault Ste. Marie, Ont.

There has been a very notable increase in the amount of paper coated in the last decade, and the industry has shown interest in improved and new methods of coating. We will present the first progress report on a system we refer to as the Kohler coating method. The report has been jointly prepared by John B. Kohler, who is the inventor and patentee, and J. R. Gunning, who is in charge of Fine Paper Research for the Provincial Paper Division of the Abitibi Power & Paper Co., Ltd., and who undertook to evaluate the system proposed by Mr. Kohler. There are obviously two points of view involved and an effort will be made to indicate, when necessary, which is being expressed.

The simplest description of the method would say that coating, which has been applied to the underside of a web of paper is smoothed and metered by a blade, of preselected thickness, which forms one boundary of the pond from which the coating is picked up, and that the paper is held against the blade by an air blast acting on the top of the paper.

Early experiments showed that the blade had to be set with the top, or working edge, exactly on the web line of the paper and the line had to be horizontal. The reasons for this are quite simple. First, if the paper were to deflect over the knife, there would be a component of the web tension forces exerting a downward pressure against the knife, or conversely these same forces would have to be overcome by the air blast if the knife were lower than the web line. The second reason is that the coating application depends on the sheet traveling over the surface of a pond of coating color which is, perforce, horizontal.

At this point reference can be made to Fig. 1 which shows most of the essential parts of the system. The horizontal web line is clear and in this section-view the paper moves from left to right. It can be seen that there are no moving parts between the roll preceding the coating operation and that after. This is a feature which is attractive, although it should be mentioned that the paper must move very smoothly from one roll to the other with good tension.

The principal piece of equipment is the tube which is beneath the web in the center of the arrangement. This has an outer shell which supports the other components as well as containing the coating color, and an inner tube through which the color is introduced and distributed evenly along the length of the outer tube, or in other words, across the width of the machine.

From the main body, the coating color rises through an adjustable slot next to the metering knife and thence across the pond bottom to fall over the back weir and into the catch pan. The flow is, therefore, from right to left and so countercurrent to the movement of the paper.

Immediately above the metering knife is the air nozzle, referred to as an air-knife at Georgetown since it came from the conventional air-knife coater. It is the air flow from here that controls the pressure of the sheet against the blade or metering knife and established the coat weight. The baffles which deflect the spent air are not shown since they are dependent on the design of the machine to which the assembly is attached and in our experience can be varied a lot.

Before the sheet passes over the pond and metering knife, it is steadied by a vacuum box, which is in the form of a narrow chevron. This unit is set exactly on the web line and is designed to provide a spreading effect to prevent wrinkles and to stabilize web tension. In the experiments thus far only light suction has been applied and on many occasions no change could be noted with or without the exhauster running. There was some evidence that operation was improved at other times.

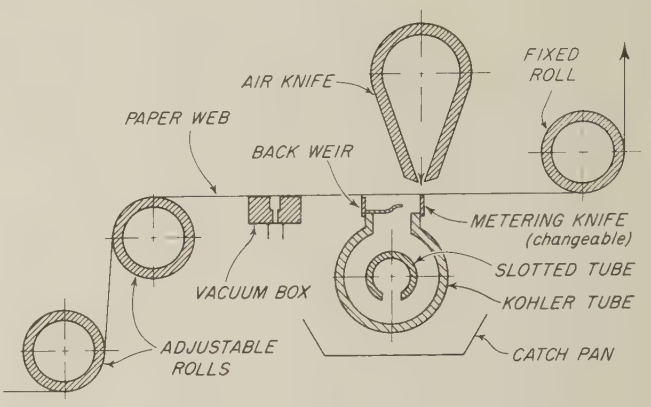

Fig. 1. Schematic drawing—Kohler method of coating

Returning to the Kohler Tube, it should be clearly understood that, while the doctoring and smoothing knife is exactly on web line, the back weir is below it. This is to insure a steady outfall of coating color, which was varied to suit the solids and rheology of the color being used, by regulating the input rate of color. It was found that adjustment of the height of the weir was desirable at times and also that a subsurface bleed at the edges of the web sometimes aided operation. The outfall color was collected in a catch pan and returned to the supply tank.

The blade design is rigid and the material used for them in the assembly we were working on was hardened, cutlery grade stainless steel. The blades we used were $^1/_4$ and $^1/_8$ in. thick and $^7/_8$ or more inches high. The top $^1/_8$ in. of each blade was thinned down to a controlled thickness, and a number of blades were made up. It was found that it was best to round the edge next to the pond (the entering side as far as the paper is concerned) and a 0.015 in. radius was established. The top was flat and smooth, and the exit edge was a square, sharp corner. It will be shown how the width of the flat is a factor governing coat weight.

BACKGROUND AND THEORY OF THE DESIGN CONCEPT

The foregoing is a description of the apparatus which has been made and tried. Before this was done, J. B. Kohler spent a long time searching for a better, simpler, more flexible coating method. It was the theory he evolved from this search that interested the Provincial Paper Division, and lead to the evaluation program. It will be given now, not perhaps as originally expounded, but confirmed and modified by experience.

Mr. Kohler had long been intrigued by the possibility of creating a coater in which the film of coating would

be attenuated by the same "hydraulic wedge" action which creates a film of lubricant in a sliding bearing. The theory of the laws applying to such bearings is, of course, well known, there is extensive literature on the subject, and the results are thoroughly proved in practice.

The rocking shoe type bearing, in particular, assumes the correct angle to suit the conditions of load, speed, viscosity, and supporting area present under a given set of conditions, and the resultant film thickness (h_0) follows a proved formula which, simplified is:

$$h_0 = k \sqrt{\frac{uVA}{p}}$$

where

u = viscosity
V = velocity
A = supporting area
p = pressure

The supporting area in the Kohler Coater is, of course, proportional to the blade thickness; the pressure is equal to the useful force exerted by the jet. Research on nozzles and jets disclose that the force of impingement of a jet on a flat plate, within the working limits we are using and with a fixed nozzle opening, is proportional to the gage pressure; and with a fixed gage pressure, it is proportional to the area of the nozzle opening. The area of the nozzle opening, in our case, is proportional to the opening between nozzle lips.

The paper web, on the other hand, is not a flat plate, but is a flexible member. However, within the narrow zone of maximum pressure which we are using, the paper web does have appreciable beam strength and appears to behave in the same manner as a flat plate, while its flexible nature permits it to assume any required angle to the blade flat, to form the hydraulic wedge.

If we were able to calculate the film thickness exactly in this formula, to predict a coating weight, we would need more accurate viscosity determinations under the exact conditions of shear existing at the doctor blade, than we have so far been able to obtain; we would need to apply consistency and density conversion factors to the film thickness; and we would need to apply some factors not yet determined to jet pressure to determine effective pressure against the blade, possibly compensating for paper stiffness or the lack of it.

Therefore, for a moment, let us fall back on empirical observation. Coating weight with a given color, a given blade, and with pressure held constant, does increase with speed. The increase is smooth, there are no critical points, and it is of a much smaller order than a direct proportion. Is it in proportion to the ratio of the square root of the speeds? It is hard to say exactly, but we think the change is not far from that ratio.

If we hold other factors constant, and change blades, the same rule seems to apply.

If we are running, at say 4 lb. pressure, and cut that to 2 lb., the coat weight goes up about 40%, or a ratio of $1:\sqrt{2}$. We do not think this is coincidence.

It also follows that the flat, smooth working surface of the blade is ideal to form the level surface now demanded of coated paper; the sharp cleavage edge inhibits meniscus formation and, therefore, leaves the surface free of pattern.

The yielding nature of the controlling force, using the paper itself as a diaphragm, ensures complete coverage and complete doctoring, but without any fibers scraped bare.

STRUCTURAL DETAILS

It is only a year ago last February at the 1958 TAPPI Convention in New York that J. B. Kohler first approached J. R. Gunning and others of the Provincial-Abitibi group with his preliminary designs. As an outgrowth of those discussions, a 15 in. pilot unit was built and delivered just about a year ago to the day.

This unit, which we have been operating at Georgetown, is the first design effort, and was originally stripped down to an absolute minimum of parts to prove or disprove the fundamental theory. Some details, such as the end-dams, were quite sketchy, and were left to be worked out in the initial tests. This was due to the fact that neither Kohler nor Gunning felt inclined to predict the exact behavior of the web in passing through the unit.

The early trials were largely devoted to improvement of details such as these dams, the pond boundary design, the color circulating and control systems, and the determination of optimum location of various elements, and working ranges of pressure, tension, and so forth. At the same time, it has been necessary to do a great deal of work on the pilot plant, which was rather crude and had a limited drying capacity. For some months the unit was installed in a wide production coating line, but the short time available for trials caused a return to the pilot plant, with a substantial rebuilding of it.

The end-dams, as finally evolved, include a small shelf at web line level, on which the dry edge rides, plus a vertical fin, or air divider, to control the nozzle effluent. The tail of this fin is outwardly curved to pull waste air off the web. This design, by itself, worked fairly well but was dependent on web tension to prevent seepage of color laterally outward. Improved designs have created a high pressure area above the shelves, thereby eliminating the complete dependence on web tension at this critical point.

The lessons learned with the 15-in. unit have provided a basis for the design of larger units now under construction. This does not come within the scope of this progress report but is rather the result of it.

In the later models, the end-dams will slide on the pond bottom, and can readily be adjusted for width, or, if required, can be equipped with automatic lateral shifting to follow the track of the web. The structure of the applicator will be arranged so that the blade and blade holder are pivoted, and form one side of the cross-machine coating supply channel. The unit, therefore, can be quickly and easily opened for cleaning or for blade change. The blade holder will include a quick acting lock for the blade, which will make it possible to change blades in a matter of seconds. The main portion of the applicator will include the return catch trough. Both this member and the blade holder can be jacketed for temperature control. The supports for the air nozzle will be carried on the end frames, and include longitudinal, vertical, and angular adjustments,

in the same way it has been found necessary to mount it on the prototype.

MACHINE CONSIDERATIONS

Because of the simplicity of the unit, it only requires some 30 in. of space in web direction, even for a wide unit. It is envisaged that it can be placed close up under a drying cylinder, or in any other convenient spot so long as the web run is horizontal and the underside can be coated. This means, of course, that the first roll or cylinder must turn the web upwards.

Good tension control across the coater is a must. Web tension plus the suction box is relied on to kill Bernoulli lift from the waste air. Positive draw elements ahead of and behind the coater, with good draw control, are recommended. Web tension has no effect on coating weight.

AUXILIARY EQUIPMENT

A multistage centrifugal blower with a capacity of 10 cu. ft. per min. per in. of nozzle width, at 5 p.s.i.g. was found to be necessary. The color system at the machine includes a pump, a suitable screen, a catch pan for the returns, and a machine chest. Every effort was made to keep entrainment of air to a minimum, and a variable speed drive was put on the pump. The color flow into and through the pond was also controlled by throttling a by-pass outlet from the applicator unit.

It was found that the lead roll immediately before the coating station should be adjustable in the horizontal plane, and the web lead should come to this roll from below rather than above. Deflectors close to this roll dissipated the waste air.

A suction blower was required for the suction box.

OPERATING CONSIDERATIONS

The coater is easy to handle. In starting up, the web is first threaded through, the machine is started, the air is turned on, and then the color is fed to the pond. In stopping, a reverse sequence is followed. It is possible to run dry with full air pressure on.

Blade changes will be a matter of a few minutes with the proposed design. No visible blade wear has become apparent in the runs to date, but, of course, the total hours on any one blade is still relatively low.

However, we look on these blades as permanent equipment subject to regrinds rather than an expendable item. There has been no grooving at web edges so far and the only effect has been a polishing action.

Dirt in the color characteristically pulled through with the paper, unassisted. Sometimes it made a short scratch in the coating, but the dirt was found at the end of the scratch. The entering radius on the knife top was applied to facilitate this action. In the rare cases in which dirt lodged against the blade, a momentary raising of the outrunning web by means of the finger or a probe caused a wet spot to run through, taking the dirt with it.

Washup will be simple and easy with future models as the entire color channel will be opened up. The new design of the air nozzle will also be opened for cleaning.

A web break in the vicinity of the coater does necessitate cleanup, if the air is on and color is in the pond when it occurs. Fortunately, this is a rare occurrence as there is nothing in the unit to catch on things like slime holes, edge cuts, or the like. Flying splices as well as properly made mill splices, have been put through with no trouble whatsoever.

Speed of operation has ranged up to 1000 f.p.m.; the limit of the machine to which it has been applied. Some chatter marks have been found in the product of runs below 300 f.p.m. on the pilot unit, but we believe these come from mechanical origins unrelated to the coating process itself. Bearing in mind that speed is one factor in the film thickness formula, we foresee no problems due to this factor alone at any speed. In other words, the other factors must be changed to compensate for speed changes to hold the same coat weight.

As far as setup is concerned, the only element to be changed to suit a given job is the blade. After a little experience, we rarely fail to make the desired weight with the first blade selected. The end-dams on the prototype are fixed, but with the new designs, it is expected that they can be set very quickly after the web has been threaded. We have normally run on one nozzle opening. However, for extreme conditions, it might be advisable to change this setting. In the new nozzle design this will be simple and quick to do.

We have not experienced any buildup of coating anywhere on the unit when running properly adjusted. The trials in this respect are not completed, but it has been observed that it is cleaner than an air-knife coater.

The following data on adjustments used may prove interesting:

Blade flat widths which have been used	0.015 to 0.235 in.
Normal range	0.030 to 0.075 in.
Air pressure in nozzle	1 to $4^3/_8$ lb.
Recommended minimum	2 lb.
Nozzle opening	0.040 to 0.060 in.
Normal	0.040 in.
Gap between nozzle and blade	$^1/_8$ to $^1/_2$ in.
Preferred	$^5/_{16}$ in.
Back weir setting	$^1/_{32}$ in. below web line

OPERATING RESULTS

Coating colors made with starch, casein, or casein-latex have been used. Both letterpress and offset furnishes have been tried, made with American or English clays as well as carbonate and satin white in various proportions. Solids have ranged from 31 to 53%, with 46 to 51% range being favored. It is planned to evaluate higher solids with the accompanying higher viscosities. Coating weights applied—and the full range seems possible at any of the consistencies tried so far—run from 2 to 20 lb. We have even had a small amount of 28-lb. coat which appeared promising.

The product in the low range of coat weights looks much like trailing blade work but without bare fibers. This confirms the original theory of smoothing and leveling with a blade, which should eliminate split film characteristics or complete dependency on base sheet smoothness.

RHEOLOGICAL CONSIDERATIONS

During some of the trials at higher speeds, that is in the range of 700 to 1000 f.p.m., there appeared some skip coat. Our explanation for this was the short

pond in the prototype which is only $1^3/_4$ in. Larger units will eliminate this fault. However, the rheology also must have had an effect since the best results were obtained with color which gave a nearly Newtonian curve on the Hercules Hi-Shear viscometer. We say *nearly* because there was a slight sign of pseudo-plasticity as well as a very narrow hysteresis loop indicating thixotropy. With color which showed noticeable pseudo-plasticity, the tendency to skip was more pronounced and there was obviously selective flow through the pond. During some of the trials, the coating trapped air because there were prolonged periods when it was circulating while adjustments were being made. This coating gave streaks but it was from an assignable cause and should not effect evaluation of the operation. Even with coating which was obviously the cause of trouble, several mechanical adjustments helped to improve the operation. One of these was the designing of a riffled pond bottom which broke up the flow pattern of the color and helped to eliminate skipping and streaks. The other was to vary the opening between the pond bottom and the metering knife.

It is realized that there is a good deal to be done to determine what coating furnishes are most suited to this coating method and their rheology. So far, the theory that has guided our color preparation has been that since the coating is smoothed with a bar there should be no leveling or after-flow. Leveling agents, wetting agents, and defoamers have for the most part been purposely left out. This may not prove to be the correct theory.

The wettability of the coating and its surface tension are properties which may have a marked effect on this method of coating. The forces at the point of wetting, and metering and smoothing, are much less than with many methods of coating so that factors which are not considered very important elsewhere may prove critical. The milder balance of forces may provide a distinct gain in controllability and be a means of applying smooth, level, heavy coat weights.

FUTURE POSSIBILITIES

It has been demonstrated that this method of coating will apply a wide range of coat weights. It has been explained why a more level and smooth surface is expected in all coat weights. Some of the studies which are included in the future plans for this project have been mentioned, but there are also other applications which may prove useful. During the development of the end-dams colored water was used and some dyed sheets were obtained which had a pleasing appearance. This is a use which can be developed. There being no moving parts it is easy to see how temperature control can be incorporated which suggests hot melts. It also lends itself to a closed system for the color which would be advantageous for volatile coatings, or those containing solvents. Perhaps the most important feature is the small space required for the machine and the ease of installation on existing equipment.

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A Bench-Scale Continuous Cellophane Casting Machine

E. E. MORSE and H. DE V. PARTRIDGE

This paper describes the construction and operation of a bench-scale, laboratory, cellophane-casting machine which was developed by Brown Company and has been used for several years for the evaluation of wood cellulose for cellophane manufacture. The machine casts a 5-in. wide gel film continuously at speeds up to 65 fpm. Purification, bleaching and washing operations are carried out batchwise on 10 to 30-ft. lengths. The purified, washed films are wound wet on heavy-walled glass tubes and air-dried. The resulting films are used for determination of film yield, color, and clarity. The effect of some variations in the viscose process on the casting operation and on film quality have also been studied. Data are presented illustrating some of the more interesting results.

The preparation of cellulose films from viscose by a plate-casting technique has been the customary procedure in laboratories concerned with the manufacture of dissolving pulp or the finished cellulose film. This process is slow and laborious, producing films which differ widely in manner of formation, and consequently in physical characteristics, from commercial films.

On the other hand, the installation required and the operating cost of a pilot-scale casting machine is very high in relation to the returns to be expected from its operation.

A number of problems connected with the suitability of wood cellulose for cellophane film manufacture required the development of a means of casting a continuous film under rigidly controlled conditions so that the factors affecting such things as film yield, color, clarity, strength, gas bubbles, and casting bath sludge could be quantitatively determined.

Such a bench-scale machine was designed and built by Brown Co. personnel several years ago and has proved to be of such value in the development of wood cellulose for cellophane manufacture that it was thought that a brief description of the machine and some of the results would be of interest to both pulp suppliers and cellophane producers.

THE CASTING MACHINE

In designing the unit, no attempt was made to build a complete cellophane machine but only those parts necessary to produce a coagulated and regenerated gel film.

The parts required are shown in Figs. 1 and 2:

E. E. Morse, Manager, Floc Division, Research & Development, Brown Co., Berlin, N. H., and, H. de V. Partridge, Assistant Manager, Pulp Research & Development, Brown Co., Berlin, N. H.

viscose supply unit, metering pump unit, casting head, No. 1 casting bath, No. 2 casting bath, take-off rolls, and gel film storage vessel.

Viscose Supply Unit. This consists of a flanged pressure vessel capable of accommodating the glass viscose containers and designed for a working pressure of 50 p.s.i.

Filtered and deaerated viscose is forced by nitrogen pressure of 50 p.s.i. through heavy-walled Tygon tubing to the metering pump.

Metering Pump Unit. A Zenith laboratory metering unit Type QE* with a 5A Zenith pump was found to be very satisfactory for the purpose. Heavy-walled Tygon tubing was used to convey the viscose to the casting head.

Casting Head. The design of the casting head is shown in Fig. 3 and consists of three parts: two face plates machined to form the hopper and the casting lips, and a backing plate containing the viscose inlet

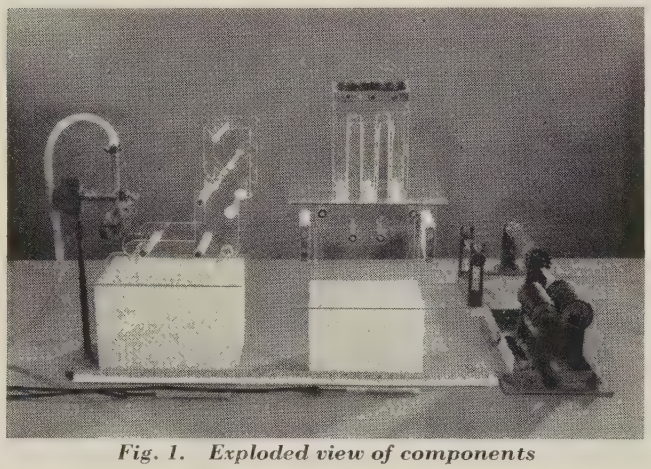

Fig. 1. Exploded view of components

and inlet screen. The width of the slot is controlled by using Teflon shims (usually 0.006 in.).

The casting head was fabricated of Illium R alloy,† which showed the required resistance to corrosion by casting-bath chemicals.

A small circular 100-mesh screen covers the viscose inlet to remove stray films and particles which could lodge in the slot and cause a discontinuity.

The casting head is held in place by an adjustable clamp as shown in Fig. 1.

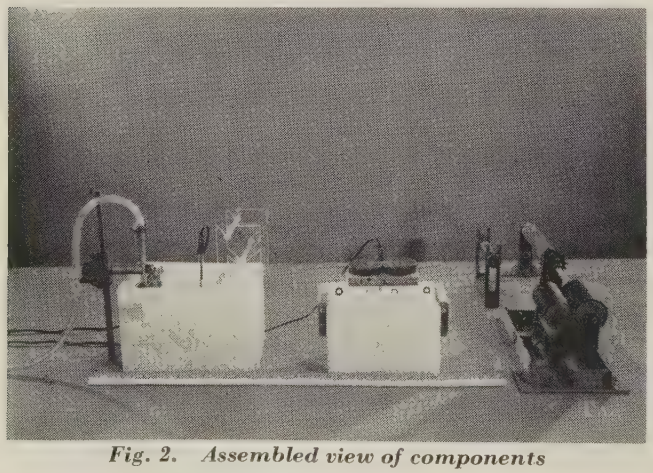

Fig. 2. Assembled view of components

* Zenith Products Co., West Newton, Mass.
† Burgess-Parr Co., Freeport, Ill.

No. 1 Casting Bath. This consists of a rectangular glass or polyethylene tank roughly 8 × 12 × 8 in. It is equipped with a removable guide roller and scraper assembly fabricated from glass rods with Lucite supporting members.

Glass tanks are excellent for visibility but are fragile, and unless it is necessary to observe the slot closely, polyethylene tanks have proved to be more satisfactory.

The temperature of the casting bath is maintained by a 500-w. Vycor immersion heater.

No. 2 Casting Bath. This bath consists of a glass or polyethylene tank 9 × 6 × $6^1/_2$ in. It is equipped with removable sets of rollers, as shown in Fig. 1, and a 500-w. Vycor heater for temperature control.

Take-off Rolls. These are shown in Fig. 1. The rubber rolls are grooved and fitted with Teflon fingers to prevent the film from wrapping on the rollers.

The rolls are driven by a $^1/_4$-hp. d.c. motor whose speed is controlled by a rheostat in the field winding.

Operating Conditions

The acid, coagulating and regenerating baths can be of any desired composition. Ordinarily the first bath would contain about 12% H_2SO_4 and 20% Na_2SO_4, whereas the second bath would be much more dilute and would contain, say, 2 to 3% H_2SO_4 and 10 to 15% Na_2SO_4. Wetting agents and other additives may be used as desired. The temperature in each bath is maintained by means of Vycor immersion heaters.

If only a small quantity of film is to be made, the acid strength need not be replenished. However, for runs of longer duration, concentrated H_2SO_4 can be slowly and continuously added to the first bath at a rate calculated to maintain the desired acidity. For extended runs, it would be necessary to use auxiliary storage tanks with chemical addition and with circulating pumps and connecting tubing.

It is not possible to duplicate all of the conditions which exist in a full-scale cellophane machine without actually building one. Control can be maintained over (a) the rate of delivery of the viscose, (b) the width of the slot in the casting head, (c) the rate of travel of the film, (d) the composition and temperature of the baths, and (e) the degree of "film-cleaning" between the two baths. If a given time of contact in the first bath is desired, then the physical arrangement of the apparatus determines the rate of travel. It is obviously not possible to vary both the time of contact and the rate of travel simultaneously.

Operation of the Casting Machine

A typical run with the casting machine would be carried out as follows:

Viscose containing 8.5 to 10.0% cellulose and 5 to 6% NaOH is prepared in advance so that at casting time it is de-aerated, filtered, and at the correct degree of maturity. A minimum amount of 3000 g. is required.

This viscose, contained in a suitable vessel, is placed inside the pressure vessel and the cover to which the delivery pipe is attached is positioned and bolted down. The Tygon tubing is connected to the metering pump and to the casting head.

The acid baths are preheated and poured into the vats.

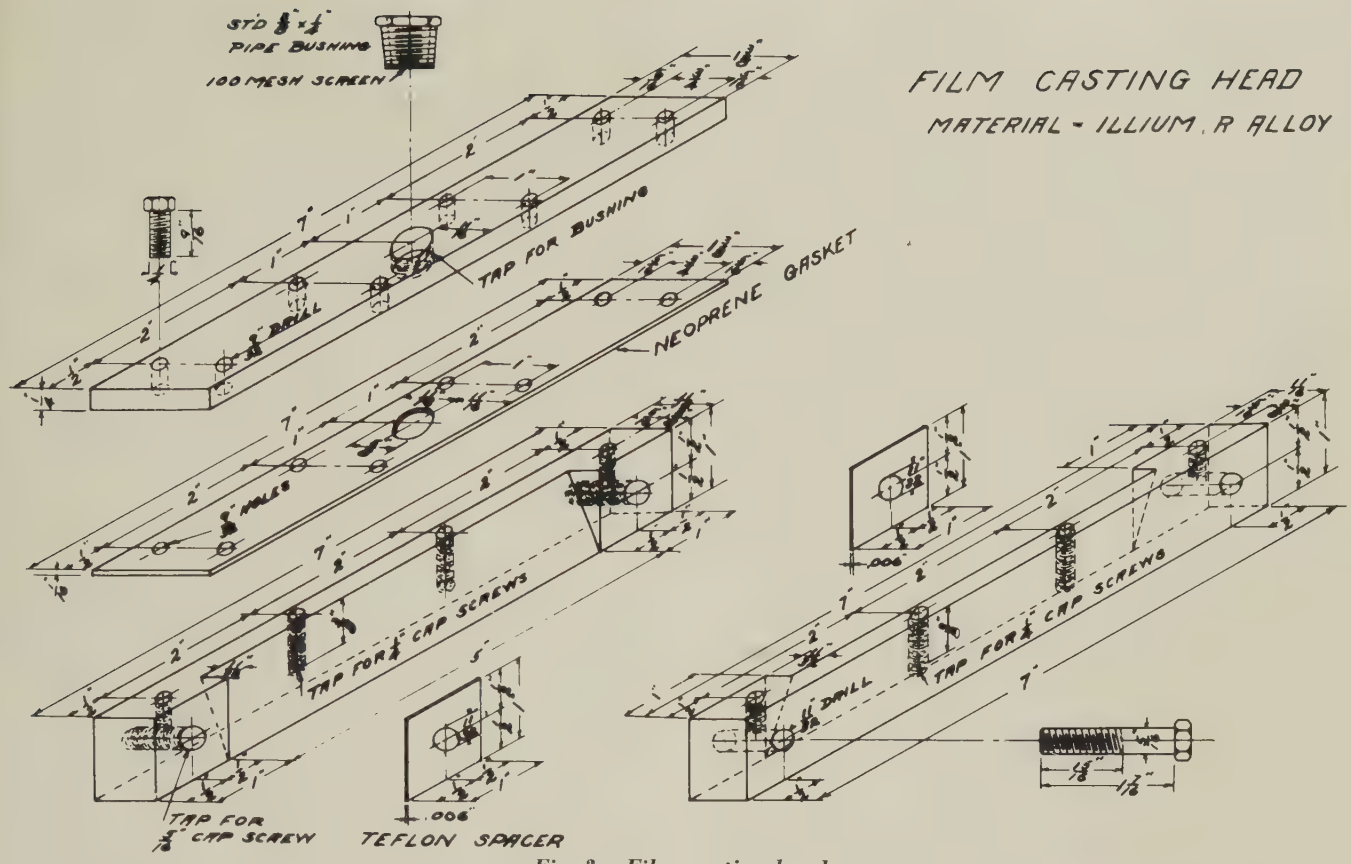

Fig. 3. Film-casting head

The speeds of the take-off rolls and the metering pump are set at a low level to simplify the start-up and threading of the film. The pump is turned on and the casting head held in an upright position with the slit uppermost until bubble-free viscose emerges. The casting head is then inverted and clamped in place with the slot $^1/_2$ in. below the bath surface.

Wearing rubber gloves, the operator clasps the blob of partially coagulated viscose and draws it through the acid bath. When a uniform sheet of gel film is obtained, an assistant places the guide rolls in place in the No. 1 bath and then positions the scraping rolls in succession as the operator continues to pull out the film by hand. Next the film is laid across the top of the second bath and the Lucite guide assembly is positioned. Thereupon the film is dropped down between the opened take-off rolls and the rolls are then closed.

The machine is now in operation and simultaneous adjustments are made of the pumping speed and the take-off speed to deliver 213 g. per min. of viscose at a take-off speed of 65 f.p.m. Difficulty may be experienced with sticking of the gel film to the rolls if the ripening index is too high or the time of contact in the first bath is too low. However, with proper adjustment of the operating variables, the machine runs smoothly.

PURIFICATION OF THE GEL FILM

The required number of gel-film samples are taken as casting proceeds by cutting the film at exactly 30-sec. intervals and collecting the lengths in distilled water at 20 to 25°C. These further purification steps are carried out in 5-gal. crocks.

Washing. The films are given three 1-min. washes in distilled water at 85 to 90°C. with agitation to remove casting bath.

Desulfuring. Films are treated with an aqueous solution of 0.25% Na_2S, 0.5% NaOH at 85°C. for 1 min. with agitation.

Washing. Films are washed in three changes of distilled water, the first two at 85°C, the third at 20°C. Films to be desulfurized only are taken out of the purification sequence at this point.

Bleaching. Films are bleached in sodium hypochlorite solution—1.0 g.p.l. available chlorine at 25°C. for 1 min.

Rinse. One wash with distilled water at 25°C.

Antichlor. Treat with 1 g.p.l. Na_2SO_3 solution at 25°C. for 1 min.

Washing. Wash three times in distilled water at 25°C. for 1 min. each.

Drying of Purified Film

The following procedure for drying films on glass tubes has proved to be very satisfactory for producing smooth film free of crease marks and suitable for color comparisons.

A length of the wet, desulfurized film is started by hand around a heavy-walled glass tube 1 in. from either end of the tube and the rewinding motor run at very slow speed. The film is tensioned and made as smooth as possible by passing over a crowned stainless steel roller. Twenty-five turns of film are wrapped on the tube.

This procedure is followed with a length of bleached film on the other end of the same glass tube so that for any pulp sample processed a desulfurized and a bleached film is available for color comparison.

The tube is then stood on end in a rack and the films air-dried for 24 to 26 hr.

The air-dried film under these conditions will have a thickness of 0.001 in.

APPLICATION OF CASTING MACHINE TO PULP AND PROCESS PROBLEMS

Determination of Film Yield

In operating the casting machine for a yield determination, it is necessary to prepare viscose quantitatively from a known, ovendry weight of cellulose. The ovendry pulp per gram of the viscose is thus accurately known.

Viscose is metered at a constant predetermined rate by the metering pump and the resulting film is collected in exactly 30 sec.

The gel film is purified according to the standard procedure and the entire length wound on a glass tube and air-dried. The air-dry film is cut off the glass tube, ovendried at 105°C. and weighed on an analytical balance.

Table I. Sludge, Color, and Yield Data on Various Dissolving Pulps

Pulp	*Casting bath sludge, g./kg. viscose*	*Relative film color*	*Film yield %*
A	0.36	3.0	94.3
B	0.34	3.5	97.0
C	0.38	3.0	93.3
D	0.42	4.0	96.9
E	0.42	8.0	94.0
F	0.38	7.0	94.5

$$\text{Film Yield, } \% = \frac{\text{Weight of ovendry film}}{\text{Weight of ovendry pulp}} \times 100$$

Results are given in Table I for a variety of North American dissolving pulps.

Determination of Film Color

A desulfurized and a bleached film from the same viscose are wound side by side on the same glass tube, according to the procedure on drying the film.

Exactly 25 turns of each film are wound on the tube and allowed to air-dry for 24 to 36 hr.

The result of drying under restrained shrinkage is to produce a smooth transparent film entirely free of air between the film layers.

Direct visual comparison with color standards can then be made, using an arbitrary 1 to 10 scale in order of increasing yellowness. Results are given in Table I showing the relative color of films from six North American dissolving pulps.

Table II. Effects of Process Variables on Sludge Formation

Sample	*Special treatment*	*Casting-bath sludge, g./kg. viscose*
Control	None	0.36
Control	With additional 18 g. Na_2S/kg. viscose	0.47
Control	2.81 P.W.R.* of the alkali cellulose	0.38
Control	2.42*	0.26
Control	None	0.34
Control	Except for xanthation in nitrogen atmosphere	0.16

* P.W.R. = press weight ratio

Determination of Casting Bath Sludge

This material is a by-product formed during the regeneration of viscose by the casting bath and precipitates largely in the first few tanks and on the rollers. It is 85 to 90% sulfur, and in laboratory work amounts to about 1.5% of the sulfur added as CS_2.

To investigate the conditions affecting the formation of sludge, the casting machine was used as follows:

1. The supply bottle of viscose was weighed before and after the run to determine the weight of viscose used.
2. A known amount of casting bath was used in each bath and was measured again after the run.
3. The machine was started up following the procedure already discussed. The film was cast continuously at 50 f. p. m. until all the viscose had been used up.
4. After the run, one fifth of each batch was set aside for analysis and kept at room temperature for 48 hr. to allow the particle size to increase.
5. The precipitate was filtered-off on a tared, hardened filter paper washed free of acid, and dried at 105°C. to constant weight.
6. The amount of sludge was calculated and expressed as grams per kilogram of viscose (8.65% cellulose).

Table II gives the results for six North American dissolving pulps.

Presented at the 44th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 23–26, 1959.

Rapid Mixed Indicator Titration Method for the Determination of Rosin Acids in Tall Oil

EDWARD H. SHEERS and LEE S. STEVENSON

Work carried out in these laboratories showed the desirability of increasing the ASTM-prescribed reflux time from 2 to 15–30 min. and of using a Beckman Model K automatic titrator for the titration. This work led to the adoption of this method by the ASTM as its referee method. The practice of titration of the alcoholic reaction solution to the two end points of Thymol Blue indicator is, however, still prevalent in industry, probably largely because many laboratories are not equipped with automatic titration equipment. Since our work showed that the equivalence points in this reaction occur at apparent pH values of 4.0 and 10.5 regardless of the tall oil sample used, and since Thymol Blue gives its second color change at an apparent pH above 11.0 in the alcoholic solvent used, it seemed desirable to work out an alternate indicator method which

Edward H. Sheers and Lee S. Stevenson, Research Division, American Cyanamid Co., Stamford, Conn.

would give results in closer agreement with the potentiometric titration method. A mixed Thymol Blue-2-naphtholphthalein indicator was found to change at an apparent pH of about 10.5 and thus gives results in reasonably good agreement with the referee method. Its use is, therefore, suggested for laboratories having no automatic titration equipment and for nonreference work.

Of greatest importance in the analysis of tall oil is the determination of its rosin acid content. Aside from chromatographic separations which have never attained any practical significance, all methods described in the literature depend on the fact that the tertiary carboxyl groups of the rosin acids are much more difficult to esterify than the primary carboxyl groups of the fatty acids.

Twitchell (*1*) esterified fatty acids-rosin acids mixtures in absolute ethanol using gaseous hydrogen chloride as a catalyst. Wolff and Scholze (*2*) used 1:4 sulfuric acid-methanol catalyst, methanol as a solvent, and a 2-min. reaction time at reflux temperature. McNicoll (*3*) introduced the use of naphthalene-2-sulfonic acid as a catalyst in 4% concentration; he used methanol as the solvent and a 30-min. reflux time. More recently, Hastings and Pollak (*4*) adapted the method of Wolff and Scholze by direct titration of the sulfuric acid and unesterified rosin acids in the reaction mixture by making use of the two color changes of thymol blue indicator; this method, with minor modifications, was adopted by the ASTM (*5*). Sandermann, Walter, and Hohn (*6*) suggested the use of *p*-toluenesulfonic acid instead of the then not commercially available reagent grade naphthalene-2-sulfonic acid. Sprengling (*7*) investigated the modified Wolff-Scholze method and suggested a 15 to 30 min. reflux period and potentiometric titration. Snell (*8*) used the modified Wolff-Scholze method and titrated potentiometrically. Linder and Persson (*9*) have suggested 1:1 benzene-butanol as a solvent, benzenesulfonic acid as catalyst, a 1 to 1.5 hr. reflux time and the inclusion of a trap to remove azeotropically all water as formed during the reaction. Hezel (*10*) reviewed the work of Hastings and Pollak and found the 2-min. esterification time insufficient; he suggested a 30-min. esterification and preferred *p*-toluenesulfonic acid catalyst. Table I shows some methods of determination of some acids.

More recently, work carried out in these laboratories showed the desirability of increasing the ASTM-prescribed reflux time from 2 to 15 to 30 min. and of using a Beckman Model K Automatic Titrator. This work, which is described more extensively in the experimental section, led to the adoption of this method by the ASTM as its referee method (*11*).

The practice of titration of the alcoholic reaction solution to the two end points of thymol blue indicator is, however, still prevalent in industry, probably largely because many laboratories are not equipped with automatic titration equipment. Since our work showed that the equivalence points in this reaction occur at apparent pH values of 4.0 and 10.5 regardless of the tall oil sample used, and since thymol blue gives its second color change at an apparent pH above 11.0 in the alcoholic solvent used, it seemed desirable to work out an alternate indicator method which would give results in closer agreement with the potentiometric titration method. It must be remembered that the relative strengths of the acids involved depend on both the charge type and the acidic or basic properties of the solvent. Furthermore, the pH meter readings obtained are only *apparent* pH values since the scale of acidity has not been thermodynamically established for the solvents used and since the potential at the liquid-liquid junction between the solvent and the saturated potassium chloride solution surrounding the reference electrode is unknown. For these reasons, pH indicators do not necessarily show color changes in the same range as they do in water. For example, thymol blue turns from red to blue over a pH range of 8.0 to 9.6 in water; this color change occurs at an apparent pH of 11.1 to 11.4 in the nonaqueous solvent system used here.

A mixed Thymol Blue—2-naphtholphthalein* indicator was found to change at an apparent pH of about 10.5 and thus gives results in reasonably good agreement with the referee method. Its use is therefore suggested for laboratories having no automatic titration equipment and for nonreferee work. Except for this, no change in the ASTM "alternate method" is suggested.

Table I. Some Methods of Determination of Rosin Acids

Author	*Date*	*Catalyst*	*Sample, g.*	*Solvent*	*Time*
Twitchell	1891	OCl Gas	...	EtOH abs.	
Wolff and Scholze	1914	H_2SO_4, 1:4, in MeOH	2–5	MeOH	2 min.
McNicoll	1921	4% NSA			
Hastings and Pollak	1939	H_2SO_4, 1:4 in MeOH, 5 ml.	4–5	MeOH	2 min.
Sandermann	1944	10% TSA	2	MeOH	30 min.
Sprengling	1947	H_2SO_4	5	MeOH	15–30 min.
Snell, C. A.	1948	H_2SO_4	Used Hastings and Pollak; pot. titration 6.0–11.0		
Linder and Persson	1949	BSA	1–10	Benzene-BuOH	1–1.5 hr.
Hezel	1950	TSA			30 min.
ASTM	1955	H_2SO_4, 1:4, in MeOH, 5 ml.	5	MeOH	30 min.

EXPERIMENTAL

Materials Used

Rosin acids, essentially free of fatty acids (prepared by repeated recrystallization of Tallex tall oil rosin acids (West Virginia Pulp and Paper Company) from methanol).

Preparation of Standard Samples

Standard samples of fatty acids containing 20, 30, 40, 50, and 60 per cent rosin acids were prepared by mixing accurately weighed quantities of the ingredients, stirring at approximately 100°C. under nitrogen until a

* Naphtholphthalein indicator is available from Matheson, Coleman, and Bell. The mixed indicator is prepared by mixing equal parts of freshly prepared alcoholic thymol blue (1%) and 2-naphtholphthalein (1%).

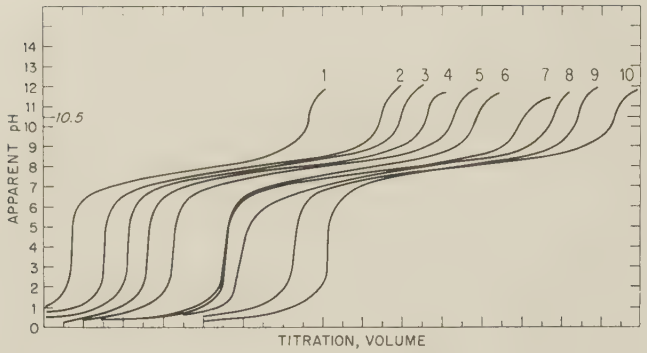

Fig. 1. Crude tall oil. Potentiometric titration of rosin acids by modified Wolff method

(1) Camp Mfg. Co. (2) Crosset Chemical Co. (3) Gaylord Container Corp. (Halifax Mill). (4) Kirby Chemical Co. (5) Albemarle Paper Co. (6) National Southern Products. (7) West Virginia Pulp & Paper Co. (Covoil) tall oil. (8) West Virginia Pulp & Paper Co. (Ligro) tall oil. (9) Southern Advance. (10) North Carolina Pulp Co.

homogeneous solution was obtained, pouring the mixture into small wide-mouth jars, sealing, and cooling the jars immediately in a refrigerator to prevent the formation of large rosin acids crystals. This procedure was used after it was found that a standard sample could not be reheated more than once without a resulting loss in rosin acids content caused by decarboxylation.

Application of the Potentiometric Titration

In a number of preliminary titrations, the end points for the rosin acids determination were found to be at pH 4.0 and 10.5. It must be noted that these are only "apparent pH" values since the titration is carried out in a nonaqueous medium. Applying this titration to samples of all commercially available tall oils (see Figs. 1 and 2), it was confirmed that titration between apparent pH 4.0 and 10.5 does give more accurate and more reproducible data than obtained visually or by interpretation of a potentiometric curve.

Variation of Rosin Acids Recovery with Reflux Time

Table II shows the percentage of rosin acids recovered from standard samples, using reflux times from 2 to 60 minutes.

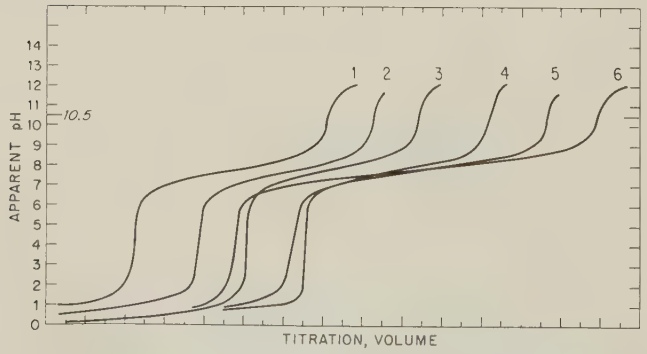

Fig. 2. Distilled and acid refined tall oils. Potentiometric titration of rosin acids by modified Wolff method

(1) Acintol D (trademark of Arizona Chemical Co.) tall oil. (2) Acosix tall oil. (3) Flextal 37 tall oil. (4) Indusoil tall oil. (5) Facoil CB tall oil. (6) Unitol R tall oil.

Table II. Influence on Determination of Rosin Acids

Reflux time, min.	*30% actual*	*40% actual*	*50% actual*
2	34.1	43.7	53.6
5	30.5	40.7	50.7
10	30.3	40.3	50.4
15	30.1	40.3	50.1
30	30.0	40.0	50.0
60	29.8	39.7	49.4

Influence of Alcohol Used for Esterification

It has been suggested in discussions that ethanol might be preferable to methanol as a solvent. Using Wecoline S soya bean fatty acids and ethanol, it was found that, under the conditions of the test, 40% of the fatty acids was not esterified after 2 min.; after 1 hr., 2.4% was still not esterified. Similar results were obtained with palmitic acid (Eastman White Label grade) which was 48% nonesterified after 2 min., as compared with 2% after 1 hr. With methanol, on the other hand, a 91.2% esterification of soybean fatty acids was obtained in 2 min. and essentially complete esterification after 15 min.

It must be remembered that while the fatty acids are being esterified, the rosin acids are also being esterified, though at a much slower rate. Purified rosin acids were found to be nonesterified after 2 min., 0.2% esterified after 15 min., 2.4% after 30 min., and 4.1% after 1 hr.

Color Change of Commercially Available Indicators in the Alcoholic Solvent Used

As can be seen from the titration curves, the curve is quite steep at the first equivalence point, and thymol blue indicator is quite satisfactory. At the second equivalence point, however, the apparent pH is changing fairly slowly with added increments of titrant and the choice of indicator becomes very important. thymol blue was found to give a very pale blue at an apparent pH of 11.1 and a blue at 11.4. Of the many indicators tested, 2-naphtholphthalein was found best for the purpose; it gave a blue color at an apparent pH of 10.2 and a deep blue at 10.5. A mixture of thymol blue and 2-naphtholphthalein turned red at the required first equivalence point and deep blue at the second. Titrations using this mixed indicator gave results within 0.5 to 1.0% of those obtained potentiometrically. For example, the synthetic samples containing 30.0% rosin acids gave 30.6% by the mixed indicator method compared to 31.7% when thymol blue was used alone.

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4. Hastings, R. and Pollak, A., *Oil & Soap* 16, 101 (1939).
5. American Society for Testing Materials, ASTM Standards, D 803–51.
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11. American Society for Testing Materials, ASTM Standards, D 803–55 T.

Presented at the 44th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 23–26, 1959.

ASSOCIATION NEWS AND EVENTS

National Conferences

Eleventh Coating Conference, Edgewater Beach Hotel, Chicago, Ill., May 23–25, 1960.

Pulp Bleaching Conference, Edgewater Beach Hotel, Chicago, Ill., June 14–16, 1960.

Fourteenth Alkaline Pulping Conference, Multnomah Hotel, Portland, Ore., Aug. 22–24, 1960.

Forest Biology Conference, Seattle, Wash., Aug. 24–27, 1960.

Eleventh Testing Conference, Pantlind Hotel, Grand Rapids, Mich., Sept. 27–29, 1960.

Tenth Corrugated Containers Conference, Royal York Hotel, Toronto, Canada, Oct. 10–13, 1960.

Fifteenth Plastics-Paper Conference, Hotel Syracuse, Syracuse, N. Y., Oct. 17–19, 1960.

Fifteenth Engineering Conference, Robert Meyer Hotel, Jacksonville, Fla., Oct. 24–28, 1960.

Local Section Meetings

Pacific: April 15, 1960, Everett, Wash., Shibley Award Meeting; May 5–7, 1960, Bellingham, Wash., or Harrison Hot Springs, Annual Meeting; September, 1960, Salem, Ore., "Modernization."

Golden Gate District (Pacific Section): Mar. 29, 1960, "Recent Advances in Materials Handling," 4:00 p.m. mill visit to Nulaid plant, dinner at Cottage Restaurant, San Leandro 6:00 p.m. May 10, 1960, True Memorial Lecture, Hotel Claremont, Berkeley.

Lakes States: March 8, 1960, mill visit Bergstrom Paper Co., Neenah; dinner at Menasha Elks Club. Theme: "Statistical Methods Applications in the Paper Industry." April 12, 1960, dinner location to be announced. Theme: C. J. West Awards. May, social meeting—date to be announced.

Delaware Valley: March 26, 1960, Benjamin Franklin Hotel, Philadelphia, Pa., 1960 Philadelphia Graphic Arts Conference; April 28, 1960, Engineers Club, Philadelphia, Pa., E. J. Albert Award Program; May 27, 1960, Beliot Eastern, Downingtown, Pa., tour and outing.

Kalamazoo Valley: March 17, 1960, Inman's Restaurant, Galesburg, "Graphic Arts"; April 21, 1960, Inman's Restaurant, Galesburg, "Stock Preparation"; May 12, 1960, Harris Hotel, Kalamazoo, Recognition Night, WMU Awards; June 21, 1960, Annual Golf Outing, Gull Lake Country Club.

New England: April 8, 1960, Management Night; June 3–4, 1960, Chatham Bars Inn, Chatham, Mass., Spring Meeting.

New England (Eastern District): Armand's Restaurant Route 9, Framingham, Mass.: March 14, 1960.

Ohio: March 15, 1960, Manchester Hotel, Middletown, Ohio, "Two-Phase Flow in a Wet Web." Speaker: Joe Parker, Beloit Iron Works. April 12, 1960, Miami University, Oxford, Ohio, a tour of the new Paper School. Subject: "High Polymers." Speaker: H. E. Whitacre. May 12, 1960, Hartwell Country Club, Cincinnati, Ohio, Ladies night.

Ohio (Indiana District): Feb. 16, 1960, Plant tour to be announced. March 15, 1960, Marott Hotel, Indianapolis, Ind. Panel Discussion, To be announced. April 19, 1960, Plant tour to be announced, "Coating," Brage Golding, Purdue University. May 17, 1960, Marott Hotel, Indianapolis, Ind., "Testing," Arthur Dreshfield, The Glidden Co.

Empire State: Whiteface Inn, Whiteface, N. Y., June 10–11, 1960.

Empire State (Metropolitan District): 465 Lexington Ave. New York, N. Y. March 8, 1960, "Coating"; April 12, 1960, "Packaging"; May 13, 1960, Ladies' Night.

Empire State (Northern District): Woodruff Hotel, Watertown, N. Y. March 9, 1960, Strength Developments in Paper; April 14, 1960, Junior Award Night; May 12, 1960, Annual Ladies Night.

Empire State (Central District): University Club, 431 E. Fayette St., Syracuse, N. Y.

Empire State (Western District): Prospect House, Niagara Falls, N. Y.

Empire State (Eastern District): Queensbury Hotel, Glens Falls, N. Y. Feb. 18, 1960, "Synthetic Fibers" (tentative); March 17, 1960, Junior Awards Contest; April 21, 1960, Symposium, "Wet End Machine Operation"; May 21, 1960, Annual Ladies' Night.

Maine-New Hampshire: June 17–18, 1960, Mountain View House, Whitefield, N. H., Annual Meeting.

Chicago: Chicago Bar Association, 29 S. LaSalle St., Chicago, Ill. March 1, 1960, Folding Cartons; April 5, 1960, Corrugating; May 3, 1960.

Lake Erie: Feb. 18, 1960, Colton Chemical Co., 6626 Union Ave., Cleveland, Ohio, plant tour; March 17, 1960, Cleveland Engineering and Scientific Center, "Off-Machine Coating with Emphasis on Waxing and Barrier Types and Base Paper Requirements."

Southeastern: March 18–19, 1960, Columbia, S. C.; May 20–21, 1960, Savannah, Ga.

Gulf Coast: March 18, 1960, Core Hotel, Panama City, Fla.; May 13,1960, New Orleans, La.

TAPPI Staff

M. A. Burnston has joined the headquarters staff as Technical Assistant. In this capacity he will work with A. J. Winchester and H. O. Teeple on various projects involving TAPPI's technical divisions.

Mr. Burnston is a graduate of Brooklyn College, a lecturer on testing techniques at Hofstra College and Rutgers University, and a member of the Packaging Institute Paper Committee and the Society of Packaging Handling Engineers. Prior to his recent move he was senior engineer and laboratory supervisor of the New York Division of Container Laboratories, Inc. Mr. Burnston is married and has two children.

Maurice A. Burnston

Mr. Burnston's broad experience in packaging and in testing techniques will make him a valued addition to the staff of the Technical Association of the Pulp and Paper Industry.

Mechanical Pulping Conference

The Fourth International Mechanical Pulping Conference will be held at the Edgewater Beach Hotel, Chicago, Ill., Sept. 19–21, 1961.

W. H. de Montmorency, Pulp and Paper Research Institute of Canada, Montreal, Que., is general chairman of the meeting, and the technical program chairman is S. R. Parsons, Consolidated Water & Paper Co., Wisconsin Rapids, Wis.

Suggestions concerning the program will be welcomed by Mr. Parsons and Mr. de Montmorency.

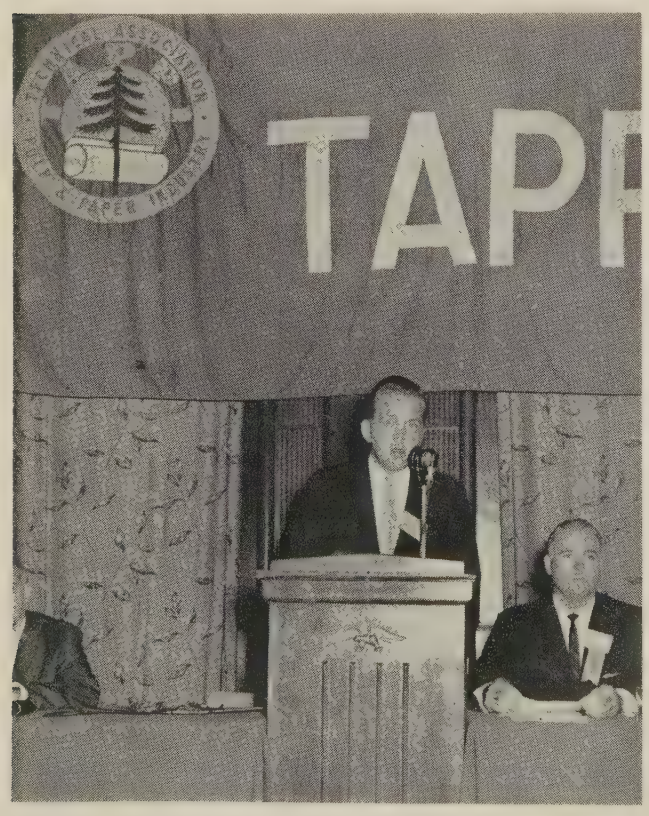
Erratum

In the author's footnote for the paper "Investigation of Some Ancient Woods" (*Tappi* 42, No. 11: 913 (Nov., 1959)) by D. J. Brasch and J. K. N. Jones, the authors affiliations were switched. Dr. Brasch is in New Zealand with the Dominion Laboratory and Professor Jones is at Queen's University, Kingston, Ont.

Ninth Corrugated Containers Conference

The Ninth Corrugated Containers Conference of the Technical Association of the Pulp and Paper Industry was held Sept. 15–17, 1959, at the Jung Hotel in New Orleans, La. A total of 335 men attended the conference. A number of wives accompanied their husbands to the conference and participated in the several Ladies' Coffees arranged for them.

J. H. Rooney, Continental Can Co. Inc., Robert Gair Products Group New Orleans, La., was the conference chairman and he received fine assistance from his conference Committee: H. R. Crais, Local Arrangements, Continental Can Co., Inc., Robert Gair Products Group New Orleans, La.; W. V. Gautreau, Continental Can Co., Inc., Robert Gair Products Group, New Orleans, La.; A. E. Richard, Continental Can Co., Inc., Robert Gair Products Group, New Orleans, La.; R. L. Kohlman, Kohlman Box Co., New Orleans, La.; G. F. Ackerman, Kieckhefer-Eddy Div. Weyerhaeuser Timber Co., New Orleans, La.



9th Corrugated Containers Conference, R. L. Jenk, Mead Containers, Cincinnati, Ohio, chairman of the Division, opening the formal meeting of the Conference. J. H. Rooney, Continental Can Co., New Orleans, La., on the right, seated

9th Corrugated Containers Conference (l. to r.): G. R. Wilmer, American Box Board Co.; J. Hamm, American Box Board Co.; R. C. McKee, The Institute of Paper Chemistry, Appleton, Wis.; H. N. Johnston, Battelle Memorial Institute, Columbus, Ohio; P. F. Hood, International Paper Co.

Wednesday, Sept 15, was devoted to committee meetings. The Steering Council and Advisory Council met in the morning. Containers Testing Committee also met in the morning. The five committees, Production, Engineering, Industrial Engineering, Raw Materials, and Process and Quality Control, met in the afternoon.

The Corrugated Containers Conference is sponsored by the TAPPI Corrugated Containers Division, R. L. Jenk, Mead Containers, Inc., Cincinnati, Ohio, chairman.

Brief reports of the technical papers are given below. The full text of the papers was reproduced and sent to each person attending the conference. They will also be published in a subsequent issue of *Tappi*.

TECHNICAL PROGRAM

The formal program of the Ninth Corrugated Containers Conference was opened Wednesday Morning, Sept. 16, 1959, by R. L. Jenk. He introduced J. H. Rooney, conference chairman who welcomed the people to New Orleans. Mr. Rooney then introduced R. C. Hutcheson, Union Bag-Camp Paper Corp., Spartanburg, S. C., as moderator for the morning session, sponsored by the Engineering Committee. The theme of the session was "Engineering Advances Contributing to the Reduction of Scrap."

Mr. Hutcheson introduced D. B. Phillips, Longview Fibre Co., Longview, Wash., who presented the first paper entitled "Less Warp, Less Gluing, More Speed." One of the functions of a corrugator belt is to remove moisture from the double-faced board as it moves over the hot plates. A belt can absorb only so much moisture. If this capacity is reduced by residual moisture then an obvious approach is to help remove moisture on the belt's return trip. To do this, a belt drier consisting of a forced hot air duct system was designed and installed. The result of judicious use of this new tool has been flatter and drier board, with higher corrugator speeds.

Concurrent with this development by the Longview plant, Mr. Phillips said the Oakland plant evolved the special double back glue machine thread-up. Several known principles already in use on corrugators were combined in a new approach. The use of thread-up rolls, the crowned spreader roll ahead of the rider roll, and offset positioning of rider roll were old procedures which were combined with crowning of the rider roll and inverse positioning of the spreader roll to

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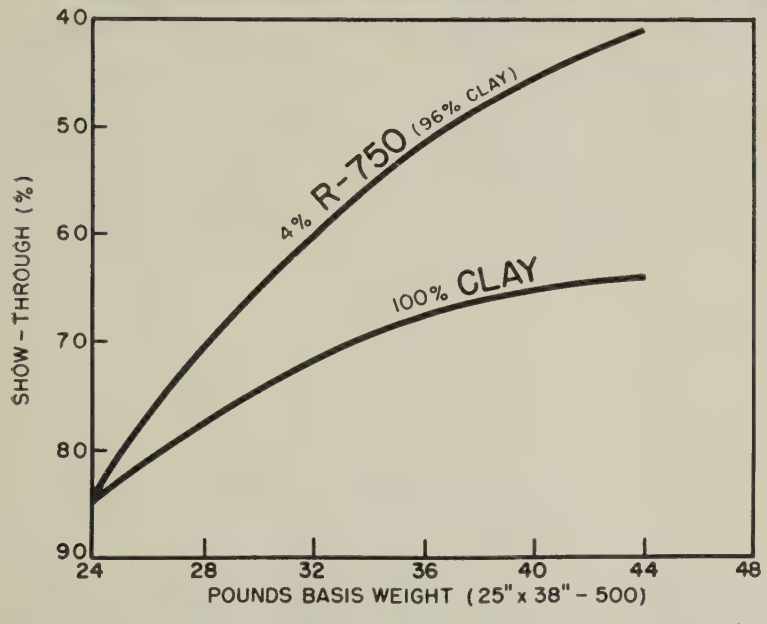

A lighter-weight sheet with greater resistance to show-through can be obtained by replacing only 4% clay with HORSE HEAD R-750 in the coating. The above results were obtained on a 24-lb. base stock coated one side only.

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9th Corrugated Containers Conference (l. to r.): R. C. Hutcheson, Union Bag-Camp Paper Corp., moderator; D. B. Phillips, Longview Fibre Co.; C. B. Lawler, Union Bag-Camp Paper Corp.; D. C. Ellinger, Downing Box Co.; P. Ziegler, Fort Wayne Corrugated Paper Co. Div., St. Joe Paper Co.

open up the single face for glue application to individual flute tips. The result is a uniform glue application along the flute tip with a marked reduction of "wet edges" due to excess glue and a notable elimination of high-lows in the center due to double back skips and insufficient glue application.

The second paper, "Waste Improvement Through Engineering," was presented by C. B. Lawler, Union Bag-Camp Paper Corp., Savannah, Ga. Materials waste, a significant cost factor in the operation of a corrugated box plant, tends to be adversely affected by greater demands on quality, service, and productivity as well as increasing complexity of products and manufacturing equipment. Mr. Lawler discussed examples where the application of engineering analysis and design have effectively assisted in the control and reduction of waste. Also, some of the more important current and projected developments were presented, including the economic desirability or "pay-off," quality tolerance requirements, design and operating feasibility, etc. Some of the items specifically covered were: accurate cut-off knife control, printer-slotter edge trim requirements, web and slitter alignment, prefeed or web tension control, splicing equipment, corrugator count control, and materials handling equipment.

"More Press Hours with Rapi-Die Register" was the third paper of the morning. D. C. Ellinger, Downing Box Co., Milwaukee, Wis., the author, opened his paper by reporting: In the spring of 1956 Downing Box Co. requested Dorr Sales & Engineering Co. of Milwaukee to study its printer-slotter operations and to direct their studies specifically toward the reduction of down time on these machines.

An analysis of the four basic elements of the printer-slotter was made, namely the feeding machines, the ink system, the printing system, and the slotting and scoring system. Mr. Ellinger stated the study disclosed that the method of mounting dies by use of staples, and the consequent time required to remove all staples after each press run or during makeready, was a major down time factor. He emphasized it was desirable to establish an improved system whereby the dies could be premounted and placed on the printing cylinder with a minimum of effort.

The next few months were devoted to the study of materials, die blankets, and the design of a mechanism for attaching the premount to the cylinder.

The result of these studies and development work is known as the Dorr Rapi-Die Register. The basic purpose of the project, the reduction of excessive down time was realized. However, it developed that improved control of register was equally advantageous.

The last paper of the morning, "Automatic Slitter Alignment Savings," was presented by P. Ziegler, Fort Wayne Corrugated Paper Co. Div., St. Joe Paper Co., Ft. Wayne, Ind. He opened his paper by stating that if a person is operating a typical 85 in. corrugator unit, he is losing about 0.93% to more than 1.87% of all the board run over his combiner in his trim removal system. Assume maximum of $1^1/_2$ in. and minimum of $^3/_4$ in. Assume average paper width of 80 in. $1.5 \div 80 = 0.0187$, $0.75 \div 80 = 0.0093$. (This goes to high side as $1^1/_2$ in. may not be absolute maximum.) Translated into dollars based on an average weekly production of 10 million sq. ft., this amounts to well over $50,000 per year. 126,000 sq. ft. per hr. $\times$ 16 hr. per day = 2,016,000 sq. ft. per day. 2,016,000 sq. ft. per day $\times$ 5 days per week = 10,080,000 sq. ft. per week. 10,800,000 sq. ft. per week $\times$ $10.00 MSF = $100,800 per week. $100,800 per week $\times$ 50 weeks per year = $5,040,000 per year. $5,040,000 per year $\times$ 1% trim waste = $50,400 per year trim waste. To date, Mr. Ziegler reported, we have saved about 5.6% of this sum. Reduced minimum from $^3/_4$ in. $\times$ $^5/_8$ in. keeping maximum at $1^1/_2$ in. Average at $^3/_4$ in. = $1^1/_8$ in., Average at $^5/_8$ in. = $1^1/_{16}$ in. $^1/_{16} \div 1^1/_8$ in. = 5.57%.

Contrary to what may be expected, this was the most tangible but least significant advantage of our slitter alignment control. With the combination of two triplexes in tandem and automatic slitter alignment other savings have been realized.

1. The simultaneous use of tandem slitters with the automatic slitter control eliminated many additional subsequent slitter operations.

2. Less attention was required on the part of the slitter operator to trim.

3. Less waste was encountered due to untrimmed sheet edges. The sequence of operation of the control was basically as follows:

1. The sensing head follows movement of the web.

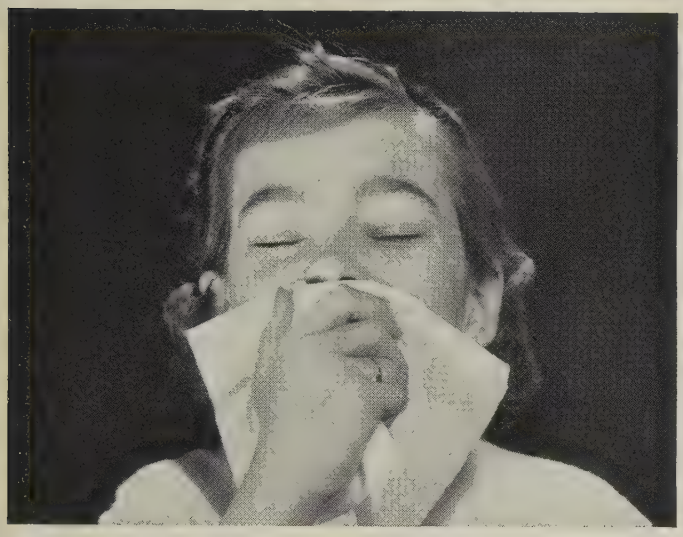
2. This movement is electrically transmitted to solenoid operated valves in the hydraulic system.

3. This simultaneously permits the piston actuating the floating arms of the sensing element and the slitters to made one complete stroke. This one stroke moved all three, the sensing element shaft and the two slitter swivel shafts, $^1/_{24}$ in.

4. If the sensing element is not yet in the neutral position, the cycle is repeated.

There are maximum limit switches to prevent jamming of

9th Corrugated Containers Conference, Industrial Engineering Committee, W. C. Kline, Container Corp. of America, chairman



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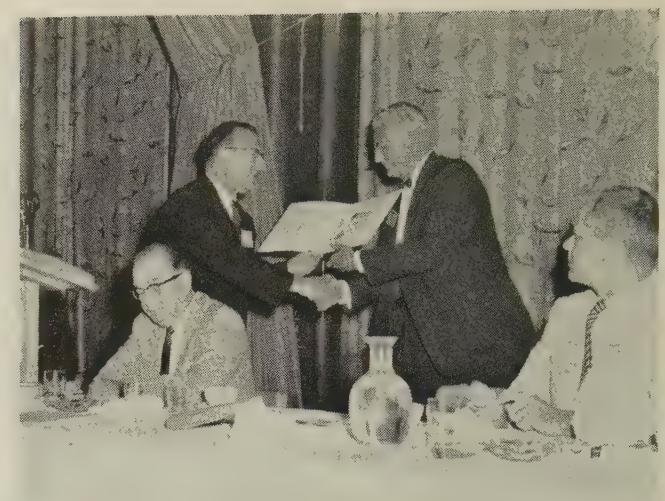
9th Corrugated Containers Conference, J. J. Koenig (l.) presenting the retiring chairman's award to K. Provo



9th Corrugated Containers Conference, J. J. Koenig (l.) presenting the retiring chairman's award to R. D. Merrill

the slitter and sensing head support at the extreme travel position.

Mr. Ziegler stated the control is hydraulically operated and is built and tracks to about $^1/_{24}$ in. The device synchronizes movement of the two slitters close enough to permit simultaneously creasing of an order on a shaft of each of the two triplexes. This unquestionably affords the greatest return, yet it is almost impossible to evaluate. It moves fast enough so that it rarely loses trim under normal operating conditions. But most important of all, the author reported, it has passed the acid test, it has been accepted by our operating personnel.

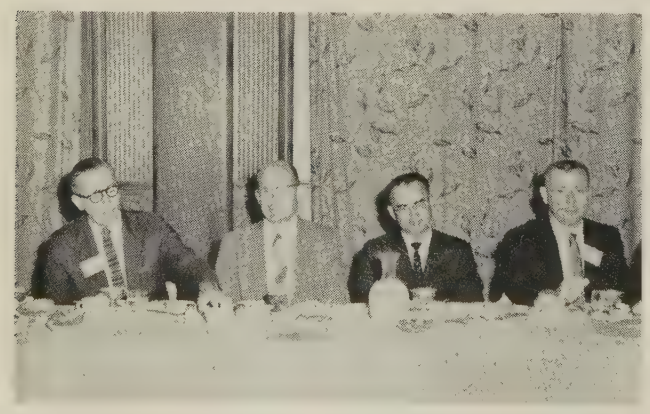
There was an informal luncheon Wednesday noon for the people attending the conference. At 2:00 p.m., Mr. Rooney introduced G. R. Wilmer, American Box Board Co., Grand Rapids, Mich., moderater of the afternoon session. Mr. Wilmer is chairman of the Raw Materials Committee, sponsors of the afternoon session. The theme of this session was "What Is Required in Corrugated Board to Compete with the Demands of Modern Packaging?"

Mr. Wilmer introduced J. Ham, American Box Board Co., Filer City, Mich., who presented the first paper of the afternoon entitled "Semichemical Corrugating Medium." Mr. Ham dealt basically in general terms with the effect corrugated medium has had and will have in meeting modern packaging requirements. He traced briefly the history of medium from the turn of the century up to the present-day semichemical methods of manufacture.

The paper also covered many of the operating problems that occur while converting semichemical medium and offered cures and remedies that have proved effectual in the past and up to the present. In conclusion, Mr. Ham discussed many of the current needs converters are presenting to semichemical producers such as, moistureproofing—development of a medium that will meet high moisture conditions and retain stiffness; also other areas currently under development that will improve the usefulness of semichemical corrugating medium.

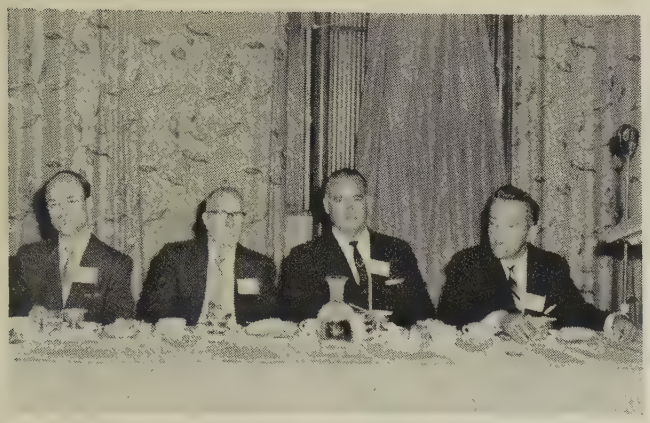
The second paper of the afternoon, "Corrugated Variables and the Effect on Combined Board Characteristics," was presented by R. C. McKee, The Institute of Paper Chemistry, Appleton, Wis. Mr. McKee reported four operational variables associated with the corrugating operation were studied to determine their effect on runability and corrugated board quality. They were speed, web tension, nip pressure, and shower pressure. Runability was determined in terms of the maximum speed at which the mediums could be corrugated without fracture of the flutes and the incidence of high-low corrugations. Corrugated board quality was measured in terms of caliper, flat crush, and adhesion. The speed at which fracture occurred varied for each medium while the incidence of high-low corrugations increased with corrugating speed. Higher nip pressure reduced the speed to fracture and lowered the tendency to exhibit high-low corrugations. Increasing the web tension had a pronounced effect on runability as measured in terms of fractured flutes; however, it appeared to have little effect on high-low corrugations or combined board quality.

"Resins and Coatings for Corrugated Board" was the title of the third paper of the afternoon. H. N. Johnston, Battelle Memorial Institute, Columbus, Ohio, was the author. He reviewed the past growth of the use of the corrugated shipping container, the current expansion into many new areas, and



9th Corrugated Containers Conference, New Orleans, La. (l. to r.): A. J. Winchester, E. O. Knapp, H. T. Scordas, L. B. Reinhart

9th Corrugated Containers Conference, New Orleans, La. (l. to r.): R. C. Hutcheson, W. P. Blamire, K. R. Martin, W. C. Kline



9th Corrugated Containers Conference, New Orleans, La. (l. to r.): P. E. Nethercut, R. J. Grierson, J. H. Rooney, R. L. Jenk

9th Corrugated Containers Conference, New Orleans, La. (l. to r.): I. Vidacovich, J. J. Koenig, K. Provo, R. D. Merrill

the prospects for its future result partially from the utilization of coatings and resins to answer to the demands of the customer.

By varying raw materials, processes, and the use of additives, the paper manufacturer can impart many desirable qualities and properties to the paper during the papermaking process. However, by the use of various resins and coatings, corrugated board can be made more useful and desirable for many applications for which it would be unsuitable in its untreated form. Mr. Johnston discussed the various raw materials and coatings that are available and that have been used to improve the properties of corrugated board. Included in the discussion are treatment of medium, over-all impregnation of board, nonslip coatings, antimar coatings, decorative coatings, and special coatings to improve the life of the container.

Application equipment that is necessary and available to handle materials used to impart these properties to corrugated board were described.

He concluded by noting that these developments and the technology available in the paint and plastics industry promise even large markets for corrugators prepared to modify board with coatings and resin.

The final paper of the afternoon, "Kraft Liners for Corrugated Board," was presented by P. F. Hood, International Paper Co., Chicago, Ill. He traced the evolution of linerboard manufactured from virgin kraft fiber from February, 1931, the beginning of mass production techniques, to the present time. The development of kraft linerboard has been a series of ever-increasing changes to satisfy the requirements of the corrugated industry. Mr. Hood cited the changes in physical characteristics and their relation to production, appearance, and strength of corrugated containers. He also discussed the role kraft linerboard will probably play in the future to meet the needs of mass production and high strength, high quality boxes.

At the banquet, held Wednesday evening, Messrs. Jenk, Provo, Merrill were each presented a TAPPI Retiring Chairman's Award by J. J. Koenig, Gaylord Container Div., Crown Zellerbach Corp., St. Louis, Mo., member of the Executive Committee of TAPPI.

Mr. Jenk announced the results of the election of the incoming officers of the division, B. Mendlin, Cornell Paperboard Products, Milwaukee, Wis., chairman; J. J. Koenig, vice-chairman, Gaylord Container Div., Crown Zellerbach Corp., St Louis, Mo.; and W. P. Blamire, American Box Board Co., Grand Rapids, Mich., Secretary.

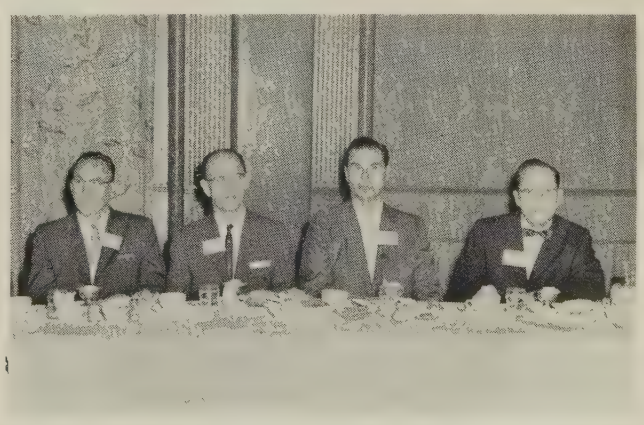
Mr. Jenk introduced as a special guest, R. J. Grierson, General Paper Mills, Melbourne, Australia. Mr. Grierson was asked to speak a few minutes on "Rule 41" and regulatory problems as they are encountered in Australia. His treatment of this assignment was both enlightening and extremely humorous.

The featured speaker of the evening was Pinky Vidacovich who, in relating many Cajun stories, amused those present.

Thursday, Sept. 17, 1959, was devoted to mill tours. One tour was an all-day affair, a visit to Gaylord Container Div., Crown Zellerbach Corp, Bogalusa, La. At this mill the tourists saw the entire mill from the woodyard through pulp manufacturing, paper manufacturing, to the box plant. It was the first visit to a completely integrated mill for some of the people. Gaylord was a most gracious host for luncheon.

The other tour was to the Continental Can Co. plant in New Orleans. An outstanding feature of this visit was the viewing of an electronic eye printing register control in action.

9th Corrugated Containers Conference, New Orleans, La. (l. to r.): R. L. Kohlman, A. E. Richard, W. V. Gontrean, H. R. Crais, D. C. Dowd



9th Corrugated Containers Conference, New Orleans, La. (l. to r.): R. W. Buttery, L. K. Burnett, F. D. Long, H. O. Teeple

TAPPI NOTES

New TAPPI Headquarters

From a one-room office in 1915 to a 6000-sq. ft. floor in 1959 may sound like the measured success of a shoe-string enterprise; yet this brief outline of 44 years of progressive expansion of TAPPI Headquarters comments favorably on the success and growth of the Association which now numbers over 9,000 individual members and 568 company members.

When TAPPI was organized, in 1915, it counted 210 individual members and the Association office, which was the same as that of the publication *Paper*, was at 542 5th Ave., New York City. T. J. Keenan, the editor of *Paper*, was the Association's first Secretary-Treasurer and the sole staff member. He held the secretaryship until 1921 when he was succeeded by W. G. MacNaughton. In 1922 the Association had 550 members and the office moved to 18 E. 41st St., New York City, with the American Paper and Pulp Association (APPA). By the time R. G. Macdonald succeeded to the secretaryship in 1927, the membership had grown to 761 and in 1928, with 901 members on the roster, it became necessary to employ two clerks, and the Headquarters' staff totaled three.

In December, 1933, the offices of the Association, together with the APPA moved to 370 Lexington Ave., New York City, and one year later, both Associations moved to 122 E. 42nd St. The area that TAPPI then rented was approximately 700 sq. ft. and comprised two rooms, an anteroom, and a storage room.

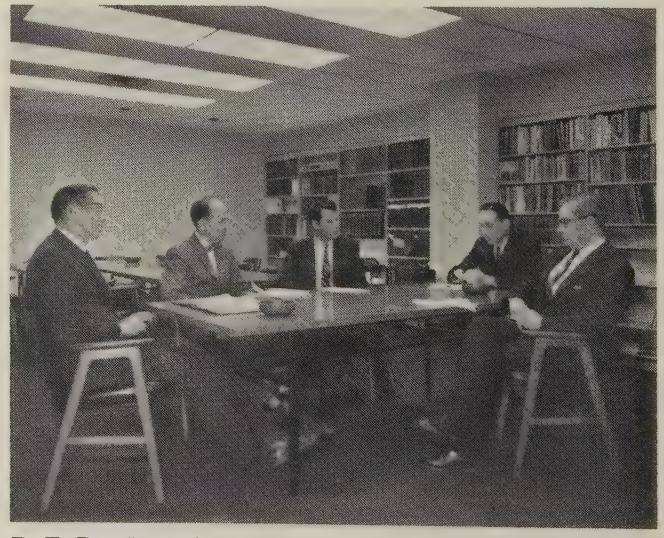
From 1938 on, with the number of TAPPI members and publications increasing, the number of employees at Headquarters grew steadily. In 1938, for example, there were five full-time staff employees (R. G. Macdonald, Vincent Waters, three clerks), and a part-time bookkeeper. The number of secretaries was increased to four in 1942, and in 1943, R. T. Bingham (editor of *Tappi*) replaced Vincent Waters as technical assistant to the Secretary.

In 1948, with membership at 3615, it was decided that the Association could better serve its members and the pulp, paper, and paperboard industries by publishing its own magazine, *Tappi*. Previously, the papers presented at Association meetings were published in the *Paper Trade Journal*, and at the end of each year these were collated and printed in a volume called *Technical Association Papers*. This decision further increased the work of the Headquarters staff, and with the arrival of A. J. Winchester in 1953, the number of staff employees was increased to six.

Anticipating further expansion and faced with the need to alleviate crowding in the offices it had occupied for 20 years, the Association moved its offices in July, 1953, to the 31st floor of 155 E. 44th St. where 3000 sq. ft. of floor space was available.

Although adequate for the first few years, these offices in turn, became inadequate as the staff was increased to keep pace with the rapidly growing needs of the Association. In 1957 P. E. Nethercut (present Secretary-Treasurer), J. W. Field, and H. O. Teeple joined the technical staff, and in 1959 M. Kouris became a member of the editorial staff. These additions, together with a corresponding increase in the secretarial staff, brought the number of employees in the middle of 1959 to 17, or with the total membership at about 9500, or one staff employee for approximately 500 members. To make room for the staff, part of the conference room used for committee meetings had to be partitioned off into offices, but it was obvious that this measure would bring only temporary relief. Besides over-

P. E. Nethercut and H. M. Annis in the reception area. Mrs. Susan Hatfield is the receptionist



R. T. Bingham, P. E. Nethercut, M. Kouris, H. O. Teeple and A. J. Winchester, in the conference room

crowded conditions the long narrow building itself, with room for private offices only at each end, had the effect of polarizing the operations of the magazine and those of the technical staff, thus isolating the editorial from the technical department. Faced with these inconveniences it was decided to look for new offices.

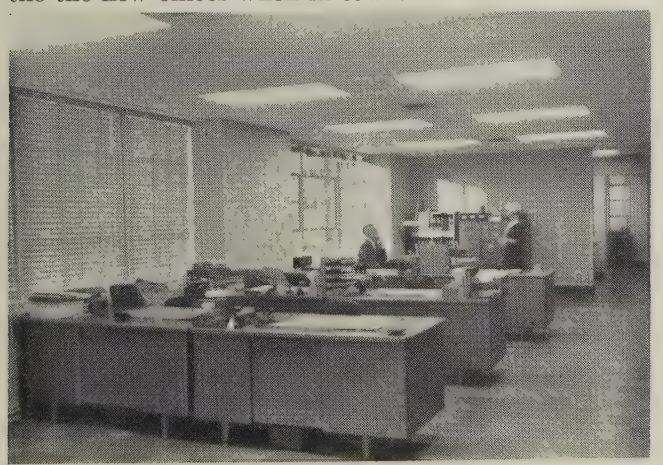
New York City, and in particular the midtown area, seemed to warrant special attention because the Headquarters would be convenient to members who were traveling to or through New York City, and wished to visit TAPPI. Upon further reflection, it became apparent that the major advantages of a midtown location seemed to be associated with the Grand Central area.

It was questioned whether TAPPI should own or lease its own building in New York City. After considerable investigation and discussion, it was concluded that the disadvantages of the Association being in the real estate business outweighed the advantages of TAPPI owning its own building.

Guided by the foregoing considerations, the quest for a new Headquarters for TAPPI ended on the 17th floor of 360 Lexington Ave., between 40th and 41st St., two short blocks from Grand Central Station and the Commodore Hotel, the site of the Annual Meeting. The present Headquarters, occupying an area of 6000 sq. ft., has provided more private offices for the larger staff which now numbers eight since M. Burnston joined the TAPPI staff in January, given the clerical staff (11) more elbow room, and allowed the inclusion of a large conference room which will also serve as a library. There is also a more spacious order-and-mailing room in which this important operation is now executed with greater ease. Although the magazine itself is being mailed from Easton, Pa., other TAPPI publications, recruiting brochure, TAPPI Monographs and Standards, etc., are handled from the Association offices.

The editorial offices have adequate space and better facilities for editing and publishing *Tappi*. More important, the proximity of the editorial and technical offices is facilitating communications and the coordination of effort of the entire staff.

The Association can be justly proud of its Headquarters. Great pains were taken to choose the location and to design the offices in connection with the needs of the members and of the staff, and a firm base for operations has been established. Association members are always welcome and should make it a point to visit the the new offices when in town.



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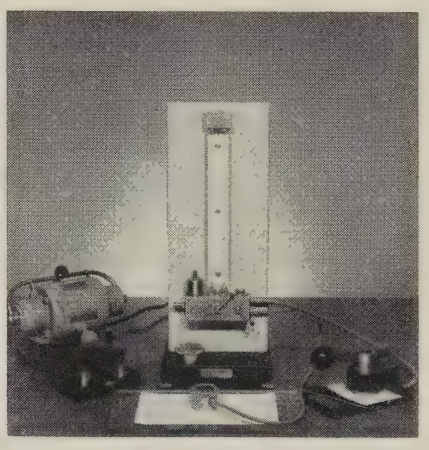

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PERSONAL MENTION

New TAPPI Members

Lars G. Ahlen, Technician, Billeruds AB, Saffle, Sweden, a 1951 graduate of Chalmers Institute of Technology.

Millicent W. E. Allen, Librarian, Imperial Tobacco Co. of Canada Ltd.

Charles H. Angell, President, Corite Products, Inc., Chicago, Ill., a 1938 graduate of Princeton University.

Michael Ansart, Technical Director, Etablissements Paul Doittau, Corbeil, France, a 1943 graduate of the University of Lyon, with a Ph.D. degree in 1951.

Marconi Archimede, Industrial Chemist, Cartiere Ambrogio Benda SPA, Milano, Italy.

Kjell E. G. Aslund, Engineer, Fiplasto S.A.C.I., Buenos Aires, Argentina, a 1944 graduate of Technical College of Harnosand.

James H. Austin, Technical Superintendent, Companhia Federal de Fundicao, Rio de Janeiro, Brazil.

Robert J. Baker, Technical Consultant, Wallace & Tiernan, Inc., Belleville, N. J., a 1941 graduate of University of Illinois.

Roswell C. Barbour, Consultant, New Rochelle, N. Y., a 1927 graduate of Buffalo College.

Claude C. Barnett, Mill Process Engineer, Olin-Mathieson Chemical Corp., Ecusta Paper Div., Pisgah Forest, N. C., a 1959 graduate of Virginia Polytechnic Institute.

Norman J. Beckman, Kimberly-Clark Corp., Neenah, Wis., a 1949 graduate of Lawrence College.

Robert A. Bennett, Chemist, Hurlbut Paper Co., So. Lee, Mass., a 1950 graduate of University of Massachusetts.

Norbert Berry, Laboratory Supervisor, Marathon Corp. Canada Ltd., Div. of American Can, Marathon, Ont., Canada, a 1954 graduate of Manchester College of Technology

Roger G. Bloomfield, Consulting Engineer, Wellesley, Mass., a 1940 graduate of New York State Maritime College.

Robert B. Boies, Project Engineer, Cincinnati Industries Corp., Cincinnati, Ohio, a 1947 graduate of University of Kentucky.

Eric J. Bohl, Research Chemist, The Metal Box Co. Ltd., London, England, a 1950 graduate of London University.

Harry R. Boone, Chief Chemist, Fels & Co., Philadelphia, Pa., a 1931 graduate of Drexel Institute of Technology.

Donald M. Booton, Process Analyst, Meredith Publishing Co., Des Moines, Ia., a 1936 graduate of Simpson College.

Berthal D. Brummet, Head, Chemical Service Laboratory, T. A. Edison Research Laboratory, West Orange, N. J., a 1947 graduate of Northwestern University.

Lawrence O. Bublitz, Technical Director, Deltox Rug Co., Oshkosh, Wis., a 1933 graduate of Illinois Institute of Technology.

Joseph E. Buonanno, Sales Representative, Metro-Atlantic, Inc., Centredale, R. I., a 1959 graduate of Lowell Technical Institute.

Philip R. Carey, Production Technical Service Chemist, Lee Paper Co., Vicksburg, Mich., a 1959 graduate of Western Michigan University.

Lawrence E. Carey, Mill Process Engineer, Ecusta Paper Div., Olin-Mathieson Chemical Corp., Pisgah Forest, N. C., a 1959 graduate of Virginia Polytechnic Institute.

Philip D. Case, Sales Representative, Bauer Bros. Co., Inc., Springfield, Ohio, a 1954 graduate of New York State College of Forestry.

Carl J. Chopin, General Foreman, Thilmany Pulp & Paper Co., Kaukauna, Wis.

Allan B. Clarke, Group Leader, Philip Morris, Inc., Richmond, Va., a 1950 graduate of Randolph-Macon College.

George W. Creighton, Jr., Process Engineer, National Vulcanized Fibre Co., Yorklyn, Del., a 1949 graduate of University of Delaware.

Thomas A. Crowe, Technical Paper Specialist, Keuffel & Esser Co., Hoboken, N. J., a 1957 graduate of New York State College of Forestry.

Julian W. Daniel, Process Engineer, Union Bag-Camp Paper Corp., Savannah, Ga., a 1954 graduate of Georgia Institute of Technology, with a Ph.D. degree from The Institute of Paper Chemistry in 1958.

Paul E. Di Benedetti, Technical Service, Paper Coatings, A. E. Staley Mfg. Co. Div., U B S Chemical Co., Cambridge, Mass. Attended Boston University.

William Dickie, Chemist, Bird and Son, Inc., Rumford, R. I., a 1952 graduate of Brown University.

John W. Ehrhardt, Student, Miami University, Oxford, Ohio.

Horst W. Erfurt, Senior Research Engineer, Hammermill Paper Co., Erie, Pa., a 1959 graduate of Technical University, Darmstadt.

Jack P. Feldstein, Sales Agent, San Juan, Puerto Rico. Attended New York University.

Hanns H. Fuehrer, Paper Mill Engineer, Westinghouse Electric Corp., Cheswick, Pa., a 1957 graduate of Laval University.

Frederick W. Furcht, Technical Sales Service Trainee, American Cyanamid Co., New York, N. Y., a 1951 graduate of the University of New Mexico.

Rovert C. Gilardi, District Manager, Air Reduction Chemical Co., Chicago, Ill., a 1944 graduate of University of Washington.

Richard H. Gilmore, Sales Engineer, du Verre, Inc., Arcade, N. Y., a 1953 graduate of University of Maine.

Victor Gilpin, Assistant Professor of Chemistry, Trinity College, Hartford, Conn., a 1944 graduate of McGill University with a Ph.D. degree.

Samuel A. Goldblith, Acting Head, Dept. of Food Technology, Massachusetts Institute of Technology, Cambridge 39, Mass., a 1940 graduate of Massachusetts Institute of Technology with a Ph.D. degree in 1949.

George A. Graham, Assistant Manager, Waste Paper Utilization Council, New York, N. Y., a 1935 graduate of Coe College.

John R. Hanzlik, Assistant Chief Engineer, The Manchester Machine Co., Middletown, Ohio, a 1948 graduate of the University of Michigan.

John Harness, Assistent Director, Technical Sales Service Dept., The Hubinger Co., Keokuk, Ia. Attended Iowa Wesleyan College.

Haruo Hashimoto, Laboratory Worker, Gooh Chemical Industry Co. Ltd., Kyoto, Japan, a 1958 graduate of Kyoto University.

Mildred M. Hill, Reference Librarian, Washington State Library, Olympia, Wash., a 1939 graduate of the University of Denver.

Akira Hirayama, Chief of Laboratory, Japan Reichhold Chemicals, Inc., Amagaski-shi, Japan.

Henry Hirschman, Process Engineer, Hudson Pulp & Paper Corp., Palatka, Fla., a 1956 graduate of Georgia Institute of Technology.

John W. Huebschmann, Chemist, A. E. Staley Manufacturing Co., Decatur, Ill., a 1953 graduate of John Hopkins University.

Lennart B. Jansson, Assistant to General Manager, Pulp and Paper Manufacturing, St. Regis Paper Co., Jacksonville, Fla., a 1952 graduate of Royal Institute of Technology.

William T. King, Mill Manager, Thames Board Mills Limited, Purfleet, Essex, England.

Kikuo Kinjo, Oriental Photo Industrial Co., Ltd., Tokyo, Japan, a 1949 graduate of Tokyo Industrial Technology Institute.

Albert S. Landers, Technical Sales & Service, Philadelphia Quartz Co., Philadelphia, Pa., a 1937 graduate of the University of Maine.

R. Valmore Le Bel, Quality Control Manager, The Frito Co., Dallas, Texas, a 1936 graduate of the University of New Hampshire.

John T. Lenihan, Graduate Trainee, The Champion Paper & Fibre Co., Hamilton, Ohio, a 1955 graduate of Case Institute of Technology.

Victor M. Levey, Technical Director, Tragacanth Importing Corp., New York, N. Y., a 1954 graduate of City College of New York.

Walter A. Littlefield, Manager, Paper Development, Brown Co., Berlin, N. H., a 1925 graduate of the University of Maine.

John Mackenzie, Technical Manager, South African Industrial Cellulose Corp. (Pty.) Ltd., Umkomaas, Natal, South Africa.

Lewis H. Mahony, Director of Technical Sales, Mixing Equipment Co., Inc., Rochester, N. Y., a 1943 graduate of the University of Denver.

Eduardo G. Malenky, Student, Tufts University, Medford, Mass.

Neal L. Martin, Chemical Engineer, Crocker, Burbank & Co. Assen., Fitchburg, Mass., a 1949 graduate of the University of New Hampshire.

Jay E. Meili, Director, Polymer Development, Freeman Chemical Corp., Port Washington, Wis., a 1948 graduate of Princeton University, with a Ph.D. degree in 1952 from Massachusetts Institute of Technology.

Herbert C. Montgomery, Sales Development Manager, Canada Colors and Chemicals Ltd., Toronto, Ont., Canada, a 1950 graduate from McGill University.

Richard W. More, Assistant Product Manager, Resins, Durez Plastics Div., Hooker Chemical Corp., North Tonawanda, N. Y., a 1947 graduate of Harvard University.

Anthony B. Newey, Technical Service Dept., Appleton Wire Works Corp., Appleton, Wis., a 1958 graduate of Massachusetts Institute of Technology.

Edmund K. Nock, Manager, Industrial Sales, General Electric Co., W. Lynn, Mass., a 1948 graduate of the University of Maine.

Joseph E. Nolan, Technical Representative, Glyco Chemicals Div., Chas. L. Huisking Co., New York, N. Y., a 1949 graduate of the College of the Holy Cross.

George E. Noponen, Senior Research Chemist, Minnesota Mining & Manufacturing Co., St. Paul, Minn., a 1936 graduate of the University of Minnesota with a Ph.D. degree.

Warren J. Norton, Midwest Manager, New York Color & Chemical Co., Chicago, Ill. Attended Northwestern University.

Kiyoshi Numabe, Chief Engineer, Rengo Shiki Co., Ltd., Osaka, Japan, a 1931 graduate of Keio University.

Robert D. Owen, Project Engineer, P. H. Glatfelter Co., Spring Grove, Pa., a 1943 graduate of Rensselaer Polytechnic Institute.

William R. Palmer, District Manager, Link-Belt Co., Shreveport, La., a 1946 graduate of Purdue University.

Emanoel Peixoto, Operating Technical Superintendent, Companhia Mineira de Papeis, Cataguases, Minas Gerais, Brazil.

Joseph F. Peter, Sales Engineer, Swenson Evaporator Co., Harvey, Ill., a 1949 graduate of the Illinois Institute of Technology.

Bengt G. Ranby, Professor, Pulp and Paper Technology, College of Forestry, State University of New York, Syracuse, N. Y., a 1940 graduate of University of Uppsala.

John C. Randall, Mill Process Engineer, Ecusta Paper Div., Olin Mathieson Chemical Corp., Pisgah Forest, N. C., a 1959 graduate of the University of Florida.

Neal G. Reddeman, Group Leader, Milprint, Inc., Milwaukee, Wis., a 1950 graduate of University of Wisconsin.

Ted Rickard, Editor, Boxboard Containers, Haywood Publishing Co., Chicago, Ill., a 1952 graduate of Loyola University.

Keith W. Roberts, Paper Chemist, Dixie Cup Div., American Can Co., Easton, Pa., a 1959 graduate of the University of Maine.

Roger L. Russell, Senior Research Engineer, Olin Mathieson Chemical Corp., Pisgah Forest, N. C., a 1952 graduate of Georgia Institute of Technology.

Paul E. Sample, Group Leader, Chemical Development, E. I. du Pont de Nemours & Co., Inc., Clinton, Ia., a 1951 graduate of Illinois Institute of Technology, with a Ph.D. degree in 1957 from West Virginia University.

Yvonne Saucier, Librarian, Georgia Forestry Commission Library, Macon, Ga.

Robert J. Schultek, Sales Engineer, Samuel M. Langston Co., Camden, N. J., a 1952 graduate of Drexel Institute.

Melvin D. Skiles, Technical Service Representative, The Hubinger Co., Keokuk, Ia., a 1955 graduate of Carthage College.

Dudley B. Smith, Manager, Licensee Services, Clupak, Inc., New York, N. Y., a 1945 graduate of the California Institute of Technology.

Joe W. Snyder, Section Leader, Pulping Research, Potlatch Forests, Inc., Lewiston, Idaho, a 1943 graduate of the University of Idaho.

Dean J. Spence, Market Research Analyst, Roger Williams Technical & Economic Services, Inc., Princeton, N. J., a 1950 graduate of Bradley University.

Aris C. Spengos, Research Associate, Scott Paper Co., Chester, Pa., a 1959 graduate of the University of Michigan with a Ph.D. degree.

George N. Streit, Corrugating Service Engineer, Stein Hall & Co., Inc., Chicago, Ill.

Clyde C. Tiffany, III, Chemist, Kansas City Star Co., Flambeau Paper Div., Park Falls, Wis., a 1954 graduate of State College of Forestry of New York.

Charles A. Trumbull, Student, University of Maine, Orono, Me.

Albert E. O'Donnell, Regional Director, Metalsalts Corp., Hawthorne, N. J., a 1930 graduate of the University of Minnesota with a Ph.D. degree from Kansas State College in 1958.

George J. Wagner, Assistant Paper Mill Superintendent, Marathon, Div. of American Can Co., Green Bay Wis., a 1950 graduate of the University of Wisconsin.

Burton Williams, Chief Engineer, Freight Loading & Container Bureau, American Association of Railroads, Chicago, Ill. Attended Massachusetts Institute of Technology.

Bertram C. Wohlafka, Technical Associate, International Business Machine Corp., Data Systems Div., Poughkeepsie, N. Y.

Julius V. Wolff, Sales Representative, Nopco Chemical Co., Newark, N. J., a 1939 graduate of Syracuse University.

Darwin C. Yackel, Senior Application Engineer, Mixing Equipment Co., Rochester, N. Y., a 1950 graduate of Iowa State University.

Thomas E. Yockey, Chemical Engineer, The Magnavox Co., Paducah, Kentucky, a 1951 graduate of Purdue University.

Roy B. Young, Jr., Chief Engineer, The Moore & White Co., Philadelphia, Pa., a 1951 graduate of Lehigh University.

Herbert A. Zuhl, Chemist, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., a graduate of Michigan State University.

Appointments

James E. Adamson, formerly of Colthrop BD & Paper Mills Ltd., is now Development Engineer for Millspaugh Ltd., Sheffield, Yorks, England.

Sylvester W. Baird, formerly of West Virginia Pulp & Paper Co., is now Superintendent for Acorn Corrugated Box Co., Chicago, Ill.

Rufus C. Barkley has been transferred from Jacksonville, Fla., to Charleston, S. C., as President of The Cameron & Barkley Co.

Raymond I. Bashford, Jr., has been transferred from Wilmington, Del., to Dayton, Ohio, as Technical Service Representative for Penick & Ford Ltd. Inc.

Bonner R. Bell has been transferred from San Francisco, Calif., to Kansas City, Mo., as Salesman for Monsanto Chemical Co.

Alexander F. Bobreski is now Group Leader in charge of Coating and Additive Departments for St. Mary's Kraft Corp.

George F. Bryant, formerly with Ludlow Paper Inc., is now Senior Management Analyst for Champion Paper & Fibre Co., Hamilton, Ohio.

Robert W. Cairns is now Member of the Board of Directors for Hercules Powder Co., Wilmington, Del.

L. O. Carlisle is now Manager, Corrugated Starch Sales for The Hubinger Co., Keokuk, Iowa.

Bayard L. Carlson is now Product Manager, Paper Industry for American Marietta Co., Seattle, Wash.

Douglas H. Clark, formerly with Fraser Companies Ltd., is now Chemist for St. Regis Paper Co., Deferiet, N. Y.

Gene M. Correll has been transferred from Covington, Va., to Luke, Md., as Analytical Chemist for West Virginia Pulp & Paper Co.

Edward L. Cowan, formerly with Bowaters Southern Paper Corp., is now Executive Vice-President for Southern Land, Timber and Paper Corp., Calhoun, Tenn.

Lowell E. Culbertson, Jr., is now Acting Mill Manager for Bowaters Southern Paper Corp., Calhoun, Tenn.

David M. Davidson, formerly with Diamond National Corp., is now with the Engineering & Research Div., Standard Register Co., Dayton Ohio.

Joa quin De La Roza, Jr., formerly with Technical Cubana S. A., is now Sales Engineer for Beloit Iron Works, Beloit, Wis.

William G. Dodge formerly with International Paper Sales Sales Co., Inc., is now Technical Advisor for Industrial Cellulose Research Ltd., Hawkesbury, Ont., Canada.

John K. Dyer is now General Superintendent, Pulp for Bowaters Southern Paper Corp., Calhoun, Tenn.

Edson J. Ferrell is now Technical Director, Technical Department for Crocker, Burbank & Co. Assoc., Fitchburg, Mass.

Edwin F. Fischer, Jr., is now Technical Control Supervisor for Neekoosa Edwards Paper Co., Port Edwards, Wis.

Edwin S. Flinn is now Executive Vice-President for Hurlburt Paper Div., The Mead Corp., Lee, Mass.

Donald G. Fox, formerly Student at N. Y. State College of Forestry, is now with the U. S. Army Chemical Centre, Edgewood, Md.

Joseph A. Fowler, formerly with Congoleum-Nairn, Inc., is now Quality Control, West Virginia Pulp & Paper Co., Luke, Md.

William G. Garlough is now Manager of Sales Research for Knowlton Bros., Watertown, N. Y.

David L. Gerrity is now Assistant Superintendent for Tennessee Paper Mills, North Chattanooga, Tenn.

Melvin F. Goyke, formerly with Thilmany Pulp & paper Co., is now Machine Designer for Marathon Div., American Can Co., Menasha, Wis.

Bert Growald, formerly with United Wallpaper, Inc., is now Research Chemist, for Allied Paper Corp., Kalamazoo, Mich.

Gordon G. Halvorsen is now Sales Manager for Great Lakes Carbon Corp., Cleveland, Ohio.

Winfred C. Hunter, formerly with New Haven Board & Carton Co., is now Superintendent for Sutherland Paper Co., Kalamazoo, Mich.

Vernon C. Iverson is now Technical Assistant to Paper Mill Superintendent, for Nekoosa Edwards Paper Co., Port Edwards, Wis.

Robert S. Ives, formerly with Ludlow Paper, Inc., is now owner of the Ives Laboratory, Allston Mass.

Charles H. Jacob, Jr., formerly with Bowaters Southern Paper Corp., has been transferred for a 5-year assignment to Tasman Pulp & Paper Co., Ltd., Kawerau, New Zealand

Jay R. Janny, formerly with International Paper Co., is now Technical Representative for Paper Pulps for Riordon Sales Corp., New York, N. Y.

Jorma J. Keino, formerly with Pulp Sales Corp., is now Technical Advisor, Finnish Cellulose Assoc., Helsinki, Finland.

Robert R. Kindron, formerly with Becco Sales Corp., FMC, is now Manager, Pulp & Paper Section for Food Machinery & Chemical Corp., Buffalo, N.Y.

Jerome J. Kipnees, formerly with Container Laboratories, is now Vice-President, Package Engineering for Atlantic Gummed Paper Corp., Brooklyn, N. Y.

Mathew A. Kuclar is now Director for the Birge Co., Inc., Buffalo, N. Y.

Jack M. Lamb is now General Manager for St. Regis Paper Co., Tacoma, Wash.

B. A. Linderholm has been transferred from Seattle, Wash., for a 2-year assignment to Stockholm, Sweden, as Executive Assistant for Sandwell A/B.

William F. Llewellyn, formerly with Marathon Southern Corp., is now Senior Project Engineer, Naheola Board Machine, for Marathon Div., American Can Co., Menasha, Wis.

Gunner Folke Lundh, formerly with Cellulose Products (PTY) Ltd., is now Director for Gunner Lundh Engineers, Stenungsund, Sweden.

Herbert W. Mackinney has been transferred from Yorktown Heights, N.Y., to Endicott, N. Y., as Staff Chemist for International Business Machines Corp.

John A. Manley is now District Manager, Wisconsin District for National Aluminate Corp.

Luciano Marrazza, formerly with Meridional Paper Mills, is now Technical Manager for Stabilimento "Cesalpinia," Bergamo, Italy.

George W. Mead II is now Product Coordinator for Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis.

Jacques B. Michon, formerly General Manager for CERIC, is now Consulting Engineer, Paris, France.

T. Ross Moore is now President & General Manager for Anglo Newfoundland Development Co. Ltd., Grand Falls, Newfoundland.

Merrill J. Osborne is now Chief Engineer for Bowaters Southern Paper Corp., Calhoun, Tenn.

Jerome E. Pinckney has been transferred from Trenton, N. J., to Savannah, Ga., as General Operating Superintendent for Union Bag-Camp Paper Corp.

Edward R. Porter has been transferred from Dallas, Texas, to Chicago, Ill., as Manager, Central Industrial Div., for Dorr-Oliver Inc.

S. Kepple Pratt is now Resident Manager for St. Regis Paper Co., Tacoma, Wash.

Richard A. Premo, formerly with Bulkley, Dunton Pulp Co., is now Assistant General Manager for Gould Paper Co., Lyon Falls, N. Y.

Robert K. Prince, formerly Consulting Engineer with Allis-Chalmers Mfg. Co., Milwaukee, Wis. is retired as of Dec. 31, 1959.

Eric S. Prior has been transferred from Whippany, N. J., to New York, N. Y., as Engineer for International Paper Co.

Penetti O. Rautalahti, formerly with Enso-Gutzeit Co., is now Assistant to Resident Manager for Ortvikens Pappersbruk, Skonsberg, Sweden.

Frank L. Rawling, Jr., formerly Student at Lowell Technological Institute, is now Graduate Teaching Assistant, Pulp & Paper Div., University of Maine, Orono, Me.

Henry Reeves is now Director, Development & Operations, Europe International Dept. for Hercules Powder Co., Wilmington, Del.

James W. Replogle, Jr., formerly with Rayonier, Inc., is now Project Engineer for Panellit Service Corp., Skokie, Ill.

Chester J. Schmidt is now Vice-President for J. O. Ross Engineering Corp., New York, N. Y.

Hans E. Schwab, formerly with Mecanica Pesada S. A., is now Engineer for Equipamentos Celulose E Papel Ltda., Sao Paulo, Brazil.

George H. Sheets is now Managing Director, Research & Development for The Mead Corp., Chillicothe, Ohio.

Richard A. Silberman, formerly with St. Lawrence Paper Co., is now Technical Director for Gould Paper Co., Lyons Falls, N. Y.

Roy C. Simon is now Section Head for Dow Chemical Co., Pittsburg, Calif.

James O. Sparks, formerly with Bowater Carolina Corp., is now Assistant Plant Manager, Containerboard & Kraft Div., for Continental Can Co., Inc., Hodge, La.

Lucien Tack has been transferred from Duffel, Belgium, to Brussels, Belgium, as Director of Service Engineering for Papereties De Belgique S. A.

Donald M. Tanguay, formerly with Cuno Engineering Corp., is now Research Chemist for West Virginia Pulp & Paper Co., Luke, Md.

Donald B. Taylor, formerly with National Carbon Co., is now Purchasing Agent for Union Carbide Corp., New York, N. Y.

Ralph N. Thompson, formerly with Calgon, Inc., is now Manager of Research for Hagan Chemicals & Controls, Inc., Pittsburgh, Pa.

Robert L. Thomsen is now Director of Marketing Analysis for American-Marietta Co., Seattle, Wash.

Austin H. Tifft is now Technical Service Supervisor for Oxford Paper Co., Rumford, Maine.

Charles E. Varn is now Assistant Director of Sales for Allied Chemical Corp., New Orleans, La.

Ivar Vestby, formerly with A/B Forenede Papirfavrikker, is now Pulp Mill Superintendent for Krogstad Cellulosefabrik A/S, Mjondalen, Norway.

Joseph J. Voci, formerly with Spaulding Fibre Co., Inc., is now Chemical Engineer for A. D. Little, Inc., Cambridge, Mass.

Frank Wabers, formerly Student at Institute of Paper Chemistry, is now Research Engineer for American Motors Corp., Detriot, Mich.

John T. Walton is now Manager of Marketing Services for St. Regis Paper Co., New York, N. Y.

Mack L. Williams has been transferred from Chillicothe, Ohio, to Lynchburg, Va., as Technical Assistant to Manager for The Mead Corp.

M. Walter Zembal has been transferred from Midland, Mich., to Freeport, Texas, as Customer Service Chemist for Dow Chemical Co.

* * *

Type "SBP" shown is completely self-supporting. Like all Johnson Joints it has no packing, needs no lubrication or adjustment. The syphon elbow replaces unwieldy curved condensate drainage pipes with two straight pipes, hinges to pass right through the joint. Write for Bulletin S-3002. Johnson Rotary Pressure Joints are available for all operating speeds, pressures, mountings.

Johnson ROTARY PRESSURE Joints
First in the Paper Industry

THE JOHNSON CORPORATION
843 Wood St., Three Rivers, Mich.

Albert E. Penney, Vice-President in charge of Pulp Manufacturing, has succeeded *Morris Wayman* as official corporate representative of Columbia Cellulose Co. Ltd., Prince Rupert, B. C., Canada, in the Technical Association.

George H. Rand has succeeded *G. Meerbergen* as official corporate representative of International Paper Co., New York, N. Y. in TAPPI.

James P. Casey, Director of Starch Sales, has succeeded *E. B. Pulse* as official sustaining representative for Union Starch & Refining Co., Columbus, Ind., in the Technical Association.

J. F. Cronin has succeeded *J. G. Henderson* as official sustaining representative for General Electric Co., Schnectady, N. Y., in the Technical Association.

H. W. Forschner, General Sales Manager, has succeeded *C. E. Buchan* as official representative for Electric Machinery Mfg. Co., Minneapolis, Minn., in the Technical Association.

Karl F. Gothner has succeeded *Arne Hallencreutz* as official sustaining representative for American SF Products, Inc., New York, N. Y. in TAPPI.

G. D. Grogan has succeeded *George R. Lawson* as official sustaining representative for Pennsalt Chemicals Corp., Philadelphia, Pa., in TAPPI.

O. H. Tousey has succeeded *D. P. O'Conner* as official sustaining representative for Penick & Ford, New York, N. Y., in the Technical Association.

* * *

American-Marietta Co. of Canada Ltd. with plants in New Westminister, B. C., and Edmonton, Alberta, is now known as Canadian-Marietta Ltd.

General Petroleum Corp., Los Angeles, Calif., is now known as Mobil Oil Co., Los Angeles, Calif.

Western Precipitation Corp. is now known as Western Precipitation Div., Joy Mfg. Co., Los Angeles, Calif.

INDUSTRY NOTES

North American

Statistics

*Production**

Paper and board production during October amounted to 3,072,786 tons. This was 5% above the 2,913,495 tons produced in October a year ago. Paper production amounted to 1,347,958 tons, which was 8% above the 1,253,182 tons produced in October a year ago. The output of paperboard during October was 1,399,881 tons, reflecting a 3% increase above the production of 1,361,663 tons reported for October, 1958.

Pulpwood receipts at the pulp mills in October amounted to 3,448,297 cords, with consumption at 3,534,564 cords. Month-end inventories decreased to 4,964,148 cords.

Consumption of fibrous materials other than pulpwood, totaled 904,128 tons in October compared to 869,469 tons in September, 1959. Inventories of 909,400 tons at month's end reflected a 1% decrease under end of September inventories. Consumption of wastepaper amounted to 815,494 tons, as compared to 805,425 tons consumed in October a year ago.

Wood pulp production during October amounted to 2,187,271 tons as compared to 2,081,634 tons produced in October, 1958. Wood pulp consumption in the paper and board mills during October amounted to 2,256,377 tons, compared to the 2,141,415 tons consumed in October a year ago.

Wood pulp inventories at end of October at the paper and board mills amounted to 522,659 tons, compared to 531,487 tons reported at the end of September. Month-end stocks of pulp mills were 257,168 tons as compared to 251,606 tons reported at the end of September.

Fiber Box Industry Outlook for 1960 and Review of 1959†

Summary

Production of the fiber box industry is expected to be the largest in its history in 1959, the Business and Defense Services Administration, U. S. Department of Commerce. Production should increase in 1959 approximately 12.5% over the preceding 3 years. The continued strong demand for fiber boxes should produce a further increase in 1960—about 5%. A build-up of inventories by the consumers of fiber boxes is expected in 1960, but this should be offset by increased retail sales.

Trends in 1959

Slightly more than 50 years old, the industry has over 400 companies operating more than 700 plants throughout the country. These plants employ over 50,000 workers and pay them approximately $250 million annually.

The industry is an important segment of our economy, and sales in 1959 estimated at $1.7 billion, represent roughly 1/3% of the nation's Gross National Product and 10% of the total spent for packaging. The metal can industry is the only other packaging industry which operates at the same level. All others are at least 20% below.

Production for the first 9 months of 1959 was within 15% of the entire year's average production in the last 3 years. The fourth quarter production averaged better than in 1958. This rate of production should establish a record breaking 110 billion square feet of board.

Fiber box production reflects the anticipated production of perishable, semidurable, and durable goods, including food, clothing, shoes, refrigerators, and stoves. Almost half of all the corrugated boxes manufactured in the country are used for packing consumer perishable items. Next to foodstuffs, semidurables such as textiles, shoes, and clothing are the largest outlet for fiber boxes.

Although less important to the industry than consumer perishable or semidurable items, the demand for consumer durables such as refrigerators, stoves, and construction supplies also increases the demand for fiber boxes.

Improved designs and new materials continue to open new markets. The use of triple wall board and combination containers, and developments in chemical coatings and waxes, all promise future expansion. Through the improved design of current containers and greater uses of triple wall board, advances should continue in the packing of heavy and dense items, products which until now have been beyond the range of corrugated board. Through the use of chemical coatings and waxes, the industry advanced further in the packing of fresh fruits and vegetables in 1959. More fiber boxes which carry fluids packed in polyethylene bags are expected to be used.

New eras are being opened in multicolor printing, especially on bleached board, which allows advertising yet furnishes a substantial shipping container which is lightweight and durable. The white color of the board provides an excellent background for multicolor advertising displays. This allows firms to take advantage of a gift-type packaging, or advertising at very low cost.

Imports account for less than 1/5% of the total volume of box shipments. Similarly, exports currently amount to less than $3 million per year.

Because empty corrugated boxes are light, have low density, and take up considerable space, transportation costs are high. Consequently, corrugated box shops are usually located close to industrial areas. Almost every major geographical area has a box shop, and no industrial area is without one.

Trends in the overall economy are the controlling factor in the industry trend. Changes in the defense program have little bearing on the volume of business as long as the Gross National Product is maintained.

In the first 6 months of 1959, shipments and demand for the fiber box industry were about the same. However, the quantities shipped to end-users exceeded the actual end use in the third quarter, indicating that consumers were building up their inventories. Inventories of raw materials were maintained at a 6-week level by the box plants, which showed no shortages of raw materials.

Outlook for 1960

The rate of increase in population is currently running about 1.7% a year, and on this basis the fiber box industry should continue its uptrend in 1960.

The Federal Reserve Board Index of Industrial Production

* Bureau of the Census, Industry Division, Paper, Printing, and Publishing. For sale by the Bureau of the Census, Washington 25, D. C. Price 10 cents—$1.00 per year.

† Source: U. S. Dept. of Commerce, Business and Defense Services Administration, Containers and Packaging Div. ER-59-46.

has increased steadily, averaging 150 in the first 9 months of 1959. As usual, the fiber box shipments index has averaged higher. The promise of a continual rise in industrial production in 1960, if realized, will substantiate expectations of the fiber box industry.

Despite some inventory buildup by users in 1959, it is estimated that fiber box demand and shipments, in square feet of board produced, will increase about 5% over the record breaking year of 1959, and be about 12.5% greater than in 1958, when 97.3 billion square feet were shipped.

Sulfur

Consumption of sulfur in the United States recovered from a 2-year decline in 1959 to reach a new record high.

In an annual review Langbourne M. Williams, chairman of Freeport Sulphur Co., said that the use of sulfur reflected the pickup of business by major consuming industries such as fertilizer, chemicals, paper, pigments, and rayon. Although demand by the steel industry dropped as a result of the strike, consumption of sulfur in all forms, according to preliminary estimates, was about 6 million long tons—an increase of better than 10% over 1958. The previous record of 5.8 million tons was established in 1956.

Exports of sulfur rose to a near-record level despite strong competition in foreign markets. Such shipments were estimated to have exceeded 1.6 million tons.

Domestic sulfur production was up slightly in 1959. Output from all sources amounted to an estimated 6.2 million long tons, compared with 6.1 million tons in 1958. Most of the increased demand was met from stockpiles of producers, who cut back stocks from 4 million tons to about 3.4 million tons.

Of the total production, an estimated 4.5 million tons were elemental sulfur mined by the Frasch hot-water process from salt dome deposits located along the coast of Louisiana and Texas. Of the balance of the output, 740,000 tons represented elemental sulfur recovered from refinery gases and sour natural gas; 450,000 tons sulfur contained in pyrites; and 510,000 tons sulfur in various forms from other sources.

Imports of sulfur, although at a high level, failed to maintain the sharply rising trend begun in 1955 with the development of Frasch-process mines in Mexico. Total imports—including Frasch from Mexico, recovered sulfur and the sulfur content of pyrites from Canada—about equaled the 755,000 tons shipped in 1958.

Overseas

Russia

Technical Information from the USSR

Technical information on research and developments in the Soviet Union is becoming increasingly available to U. S. scientists. Soviet periodicals are to be found in all science, special libraries, and in almost all large public libraries in the country. Furthermore, Russian textbooks and personal subscriptions to periodicals are easy to obtain.

Although such sources of information may be of immediate value to those with a knowledge of Russian, most scientists in the U. S. depend heavily on English translations of the original works. To meet the ever growing demand for technical translations, many translation services are available, among these is the office of Technical Services (OTS*), the U. S. Government Center for the collection and distribution of translated Russian and other foreign technical material.

Thousands of complete translations and many more thousands of abstracts of articles and books are prepared each year by agencies of the Federal Government for their own use and turned over to OTS for cataloging, reproduction, and sale to science and industry at the cost of reproduction and handling.

As soon as new translations become available, they are announced in the OTS bibliographic publication *Technical Translations*, published twice a month and sold by OTS at $12 a year, or 60 cents a single issue. Also listed are translations which will eventually be available to the public. Added to the OTS-controlled material listed or abstracted in *Technical Translations* are translations sold by the Special Libraries Association (SLA) Translation Center and many other government and private organizations. Thus, *Technical Translations*, published in cooperation with SLA, is designed to serve as a central source of information in the United States on translated material available to the public.

Also available on subscription are the following:

Scientific Information Report, a twice-monthly review by the Central Intelligence Agency of scientific and technical advances in the U.S.S.R., Eastern Europe, and Red China in chemistry, earth sciences, electronics, engineering, mathematics, medicine, metallurgy, physics, and other areas, $28 a year, $2.75 a single issue.

Abstracts of all articles appearing in each issue of approximately 100 Russian technical journals.

The sources of Soviet scientific information and translations have been the subject of two useful pamphlets: "Providing U. S. Scientists with Soviet Scientific Information," has been prepared by the office of Science Information Service, National Service Foundation (May, 1959); and "Scientific Translations, A Guide to Sources and Services," Public Health Service Publication No. 514 (Rev.).

These publications are convenient sources for locating and procuring prepared translations of scientific papers filed in special centers in the United States and foreign countries, for obtaining information on all Soviet publications currently available in cover-to-cover translations, and for obtaining information on dealers of Soviet Publications in the U. S.

India

Construction of Bagasse Fine Paper Mill

The beginning of construction of Mandya National Paper Mills Ltd. in Mysore State, India, recently has been announced jointly by the Parsons & Whittemore/Lyddon Organization of New York, London and Paris and Bedi & Co. (Private) Ltd. of Bangalore. It will be an integrated pulp and paper mill with an initial capacity of 35 tons per day of high grade writing and printing papers produced from sugar cane bagasse pulp.

Technical services including supervision of construction and initial operation are being performed by the Parsons & Whittemore/Lyddon Organization. Bedi & Co. and Parsons & Whittemore will act jointly as managing agents. Parsons & Whittemore is also supplying the complete package of production machinery, orders for which have been placed with equipment manufacturers in France and the United States.

Financing of the mill has been obtained with the help of credits granted by the French Government to India and with the assistance of the Industrial Finance Corp. of India. Ground has been broken on the mill site and erection of the plant buildings is under way. The mill is expected to go into production during 1961.

The Parsons & Whittemore/Lyddon Organization, drawing upon its extensive experience in supplying complete mills to the international pulp and paper industry, will furnish Mandya an integrated plant which will be self-sustaining except for electric power and some chemicals obtainable locally at favorable rates. Abundant quantities of sugar cane bagasse, the primary raw material, will be

* Address: U. S. Dept. of Commerce, Office of Technical Services, Washington 25, D. C.

made available by Mysore Sugar Co. Ltd., located near the paper mill site at Belagula between the cities of Bangalore and Mysore.

The bagasse pulp mill will employ a combination of moist depithing at the sugar mill and wet depithing at the pulp mill for elimination of all dirt and nonfibrous material from the raw bagasse. This treatment yields an easily beachable fiber suitable for the manufacture of the highest quality white papers. The pulping operation will be conducted in a Black-Clawson Pandia continuous digester in accordance with techniques applied by Parsons & Whittemore to the pulping of a wide variety of agricultural fibers.

A 138-inch wide fourdrinier paper machine and all auxiliary papermaking equipment, as well as a liquor burning and chemical recovery system will be supplied.

The Mandya mill will produce substantial quantities of writing and printing papers for the Indian market. At present, the annual per capita consumption of all papers in India is only 2 lb. as against 420 lb. in the United States.

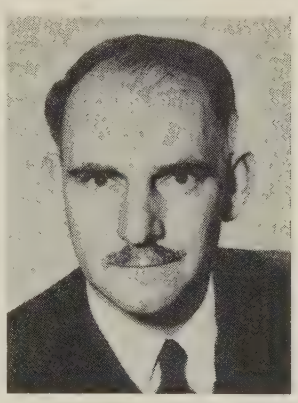
Paper Manufacturers and Converters

The Black-Clawson Co.

To Serve Australia and New Zealand

The Black-Clawson Co., international manufacturer of pulp and paper mill and converting plant equipment, has formed a sales and technical service subsidiary to represent its products to the Australian and New Zealand paper industry. The establishment of Black-Clawson (ANZ) Pty. Ltd. was announced by Frank Peterson, president of the parent firm.

Norman T. Jelbart has been appointed managing director of Black-Clawson (ANZ) Pty. Ltd. with offices at 374 Little Collins St., Melbourne, Australia. Mr. Jelbart is a chartered engineer with more than 20 years' experience in the pulp and paper industry including responsibilities as a construction engineer and development manager for new plants and processes. During recent months he has studied the complete Black-Clawson equipment line in many operating installations and at the Pandia, Shartle, Dilts and Paper Machine Divisions in the United States and at Black-Clawson International in England.



Norman T. Jelbart

The equipment supplied by Black-Clawson (ANZ) Pty. Ltd. includes the Pandia continuous pulper and other pulp mill equipment; complete Shartle stock preparation systems including refiners, cleaners, screens, pumps, and agitators; every type of paper and paperboard machine and auxiliary equipment; and a wide variety of Dilts machinery for converting paper and plastics. This equipment will be manufactured in the plants of Black-Clawson either in the United States or England.

Newprint Machines for Russian Mills

The Parsons & Whittemore/Lyddon Organization of New York, London, and Paris, has closed a contract with Techmashimport, Moscow, for two high-speed newsprint machines to be manufactured by the Black-Clawson Co., for delivery to Russia in 1962 and 1963. The machines and auxiliary equipment will be manufactured substantially at the foundry and machine works of Black-Clawson International in Newport, England.

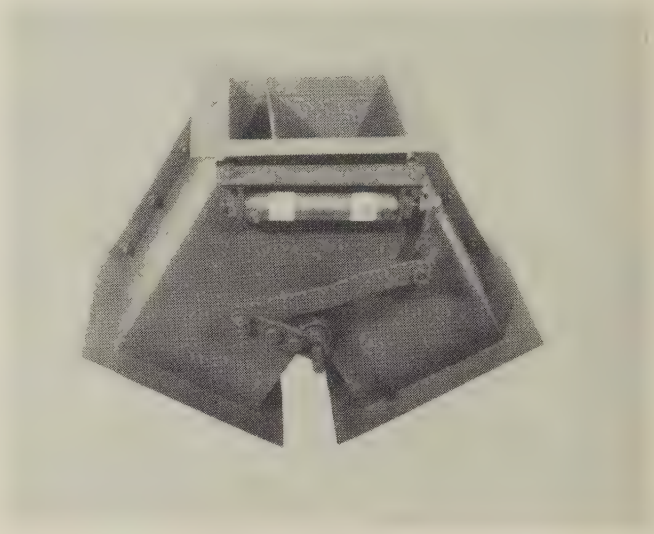
The value of the order exceeds £4,300,000 ($12,000,000) and was obtained for Black-Clawson against the heaviest competition in recent years from other major paper machine builders in the United States, Germany, England, Sweden, and Finland.

Identical machines, they will be the largest in Russia—each, 284 inches wide. Designed mechanically for speeds up to 3000 f.p.m., they will operate initially in the 2000 to 2500 f.p.m. range, producing 330 metric tons per day of standard newsprint, trimming 265 inches.

The Bucket Elevator Co.

Bifurcating Gates

A new line of bifurcating gates for diverting a stream of bulk material is now available from The Bucket Elevator Co., Summit, N. J. Gates feature one removable side for easy cleaning. Movement of the gate is by tilt bar for hand operation or by air cylinder.



Bifurcating gates

Buckeye Cellulose Corp.

Safety Record Now 5 Million Man-Hours

Employees of Buckeye Cellulose Corp.'s pulp plant in Memphis, Tenn., tightened their hold on the world's safety record for the pulp and paper industry. On January 2, they extended their injury-free performance to more than 5,000,000 hours.

More than 600 employees of the plant have worked since Jan. 22, 1956, without a disabling injury.

"Our new goal is 6,000,000 man-hours, which we should reach in the first part of 1961. It will take a lot of planning, thinking, and acting safely to reach this goal, but I believe we can do it."

Cadillac Associates, Inc.

Appointments

Lon D. Barton, president of Cadillac Associates Inc., announced the appointment of Norman Mayell as an associate counselor in the paper industry division at Cadillac, working with Fred Steffens, director.

Canada Paper Co.

Clupak Production Begins

The second Canadian paper company to start production of Clupak paper is Canada Paper Co. St. Lawrence Corp., Ltd. began making the first Clupak paper in Canada in August, 1959.

Canada Paper Co., the ninth of Clupak, Inc.'s licensees to go on line this year, is producing the new paper at its Windsor Mills, Que., plant on its no. 5, 138-in. wide machine, which has a production capacity of approximately 100 tons a day.

Consolidated Water Power & Paper Co.

Appointments

Pierre A. Fifi has joined the Research and Development Staff as a project chemist. Mr. Fifi is a native of Belgium where he received a degree in chemistry in 1949. He has been employed in that country by National Center of Metallurgical Research.

R. J. Mader, Biron Division manager, has announced the appointment of Harold Andraska as foreman of the sheet metal department and Anton Radtke as assistant mechanical maintenance foreman. Mr. Andraska started with the company in 1936. Mr. Radtke has been employed by the company since 1924.

Crocker, Burbank & Co.

Appointment

Edson J. Farrell has recently been appointed Technical Director of the Technical Department at Crocker, Burbank & Co., Assoc. Mr. Ferrell joined C. B. & Co. in 1951, after 14 years with Fraser Paper Ltd. in Madawaska, Me.

His new duties cover the supervision of production, quality control, and new product research and development in the company's industrial, book, and Bristol papers. He is a member of TAPPI and also a member of the Executive Committee of the New England Section of TAPPI.

Dietz Machine Works

Larger Plant

Dietz Machine Works, Inc., has moved into its newly acquired building at 20 W. Berkley St., Philadelphia 44, Pa. The new plant affords four times the manufacturing area of the old and is designed for modern streamlined single-floor operation.

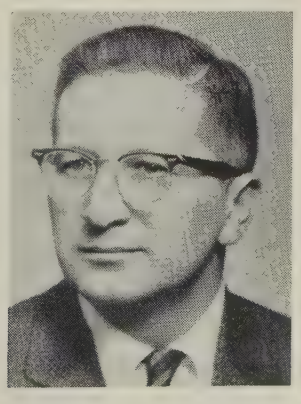
A leading maker of napkin, towel, toilet paper and facial tissue machines, tube-winding equipment, slitters and rewinders, embossers and other machinery for paper converting, Dietz had been located for the past 60 years at 126 W. Fontaine St. in Philadelphia.

Appointment

Arthur Pezzoli has been appointed vice-president in charge of manufacturing by Dietz Machine Works.

Widely known for his work in developing quality standards for paper converting production equipment, Mr. Pezzoli had been on the staff of Scott Paper Co. for the past eight years, most recently as Converting Equipment Engineer. His prior experience in the field included service as assistant chief engineer of Keasbey and Mattison Co.

Edson J. Ferrell, Crocker, Burbank & Co.

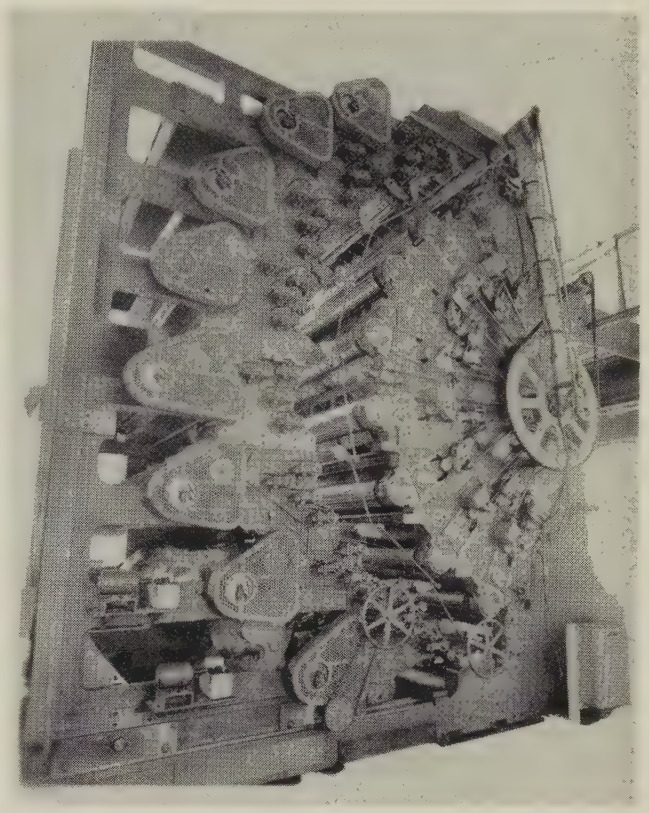


Arthur Pezolli, Dietz Machine Works

Crown-Zellerbach Corp.

8-Color Rotary Letterpress

Kidder Press Co., Inc., announces the shipment of a huge, 8-color rotary letterpress to the San Leandro, Calif., plant of the Crown Zellerbach Corp. The press, 72 in. wide and with a top operative speed of 1000 f.p.m., is designed for



Eight-color rotary letterpress at Crown Zellerbach's San Leandro, Calif. plant

"process printing" of paper materials for breadwraps and frozen food wraps. Weighing about 130 tons, this modern, heavy duty press required four freight cars for shipment across the continent.

Dillard Paper Co.

Appointments

Ernest H. DeLong has been named general manager of the Atlanta sales office and warehouse of Dillard Paper Co., according to Edwin R. Dillard, president.

Currently a director of the Atlanta Chapter, Printing House Craftsmen and the Atlanta Advertising Club, Mr. DeLong is also a member and past director of the Atlanta Litho Club and a member of the Printing Industry of Atlanta.

Dillard Paper Co., with headquarters in Greensboro, N. C., is a major supplier in the Southeastern states of printing, industrial and packaging papers, and has branch offices in 16 cities.

Federal Paper Board Co.

Merger with Manchester Board and Paper

The Federal Paper Board Co. has arranged to acquire the Manchester Board and Paper Co., Inc., of Richmond, Va. The acquisition will add approximately $9 million to Federal's sales. Combined sales of the two companies for 1959 will be in the vicinity of $86 million.

Plans for the merger were announced jointly by John R. Kennedy, president of Federal, and Frank E. Brown, Man-

chester's president, who will become a director of Federal.

Under the terms of the merger agreement, each share of Manchester's 300,000 shares of outstanding common stock will be exchanged for 0.38 common shares and 0.81 shares of 4.6% cumulative preferred, $25 par, stock of Federal Paper Board. This exchange will require the issuance of 114,000 additional shares of Federal common stock and 243,000 shares of preferred stock. On completion of the merger, Federal will have oustanding approximately 1,183,000 shares of common stock and 587,000 shares of preferred stock.

Federal, with 18 plants in the East and Midwest, is one of the nation's largest producers of boxboard and cartons, and an important manufacturer of machine-made glassware. Manchester operates three paperboard mills, two in Richmond, Va., and one in Roanoke Rapids, N. C. This section of the country is contiguous to the market areas now served by Federal's paperboard mills and carton plants.

Hurlbut Paper Co.

Appointments

Edwin S. Flinn, has been elected executive vice-president of Hurlbut Paper Co., South Lee, Mass. He assumed the duties of the chief executive officer of the company upon the retirement of E. A. Sitzer on December 31.

Dr. Flinn, a Mead employee since 1945, had been assistant to the president of Hurlbut Paper Co. since January, 1959. Hurlbut, a leading producer of technical papers for the decorating and industrial laminating industries, is a subsidiary of The Mead Corp.

E. A. Sitzer Retires

Mr. Sitzer was elected president of the company in 1936, two years after he joined the firm as a sales representative. Hurlbut's reputation today as a leading producer of technical papers for the industrial and decorative laminating industries is attributed to his leadership.

Although Mr. Sitzer has retired from active management, he will serve as chairman of the board of directors and will be available for special assignments.

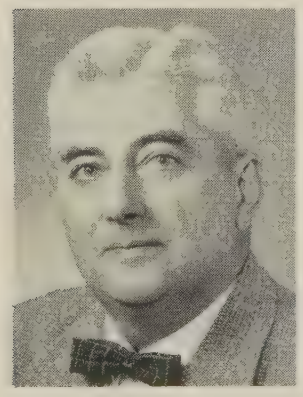
Huyck Corp.

Appointments

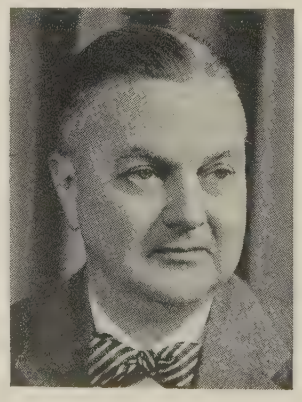
Arthur S. Hayeslip has been appointed vice-president in charge of sales for the Huyck Felt Co., Rensselaer, N. Y., a division of Huyck Corp. The announcement was made by Frederic A. Soderberg, vice-president of F. C. Huyck & Sons and general manager of the Huyck Felt Co., at the annual marketing meeting held recently at Garden City, N. Y.

The appointment of Mr. Hayeslip fills the vacancy created when Mr. Soderberg assumed the responsibility of general manager of the Huyck Felt Co.

Clyde J. Pate has been appointed felt sales engineer for the Southwestern States.



E. S. Flinn, Hurlbut Paper Co.



Arthur S. Hayeslip, Huyck Felt Co.

Knowlton Brothers

Appointments

William G. Garlough has been promoted to the newly created position of manager of sales research.

In his new position Garlough will be responsible for new market development, marketing research, and sales statistical records.

John E. Cornaire has been appointed assistant purchasing agent.

Manistique Pulp & Paper Co.

Mills Purchased by Field Enterprises

Field Enterprises, Inc., have purchased the Manistique Pulp & Paper Co. of Manistique, Mich., from the Trenton *Times* Newspapers and the James Kerney Foundation.

Wilbur C. Munnecke, a vice-president of Field Enterprises, was elected president of the Manistique mills which have an annual production capacity of over 30,000 tons of paper, largely newsprint. Frank S. Hoholik, manager of the mills for many years, was elected a vice-president and named general manager. Both Munnecke and Hoholik were also elected directors of the company.

Mead Corp.

Appointments

George F. Martin, William H. Brickner, and William A. Wheeler are named to top staff positions at Mead's New Products Division in Cincinnati, Ohio.

Mr. Martin, as products development manager, will supervise the administrative activities of the various product managers and pilot plant superintendents; Mr. Brickner, products planning manager, will assist the director of the division in uncovering, screening, and evaluating new ideas for further study; and Mr. Wheeler, chief engineer, will be responsible for developing new production and assembly machinery.

All will report directly to Allyn C. Beardsell, division director.

Mead's New Products Division will occupy modern offices and laboratories in a remodeled section of a large manufacturing plant purchased by Mead early in 1959 at Marburg Ave. and Madison Rd.

R. H. Savage, vice-president of The Mead Corp., has assumed new duties; his extensive experience in the technical field will be concentrated on the development of a number of future corporate projects.

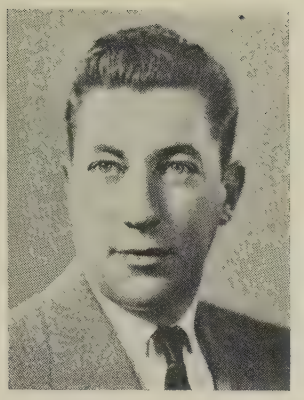
At the same time, the following additional changes in personnel were announced by President D. F. Morris.

George H. Sheets, manager of Mead's Chillicothe Division, has been appointed managing director, research and development, with responsibility for direction of Mead's current

Russell H. Savage

George H. Sheets

Hoyt H. Wheeland



Hugh A. Black

programs in research, development, corporation technical service, and related functions.

Hoyt H. Wheeland, production manager, Chillicothe Division, has been appointed division manager, succeeding George H. Sheets.

Hugh A. Black, director of industrial relations, has assumed the chief responsibility for the industrial relations department, succeeding A. J. Miller, Jr., who died in December.

Nekoosa-Edwards Paper Co.

Appointments

Promotions for two technical department staff members of Nekoosa-Edwards Paper Co., a leading producer of business papers, have been announced.

Vernon C. Iverson was named technical assistant to the paper mill superintendent of the Port Edwards mill. A graduate of Luther College, Decorah, Iowa, Mr. Iverson also did graduate work at the University of Oklahoma before joining Nekoosa-Edwards as a research chemist in February, 1951. He has been technical control supervisor at the Nekoosa mill since November, 1953.

Edwin F. Fischer, Jr., was advanced to the position of technical control supervisor in the Nekoosa mill. A chemical engineering graduate of the University of Wisconsin, Fischer was with the technical staff of Gilbert Paper Co., Menasha, for 6 years before joining Nekoosa-Edwards as research engineer in January, 1955. He has been technical control supervisor and chemical engineer in the Port Edwards mill since August 1957.

Three Foremen Named

Promotion of three men to foremen in the Port Edwards mill of Nekoosa-Edwards was recently announced.

Arnold J. Driscoll was named maintenance foreman, Donald L. David was promoted to foreman in the finishing department, and James P. Pazurek was named foreman in the shipping department.

New York and Pennsylvania Co.

Fiber Recovery Units Added

Continuing its program of modernization, New York & Pennsylvania Co. recently announced that two Colloidair Flotation savealls are now being installed in the company's Castenea Mill at Lock Haven, Pa. These are in addition to four similar units already in operation at the company's Johnsonburg (Pa.) mill and six others operating at its Lock Haven (Pa.) mill.

Strathmore Paper Co.

Appointments

Charles E. Benoit, Superintendent of Strathmore's no. 1 mill in Woronoco, has been appointed manager of the two Strathmore Woronoco mills and village properties. Mr. Benoit replaces Harold A. Bolles, and is succeeded by Donald Bush, who has been assistant superintendent.

St. Paul and Tacoma Lumber Co.

Appointments

The following senior executives of St. Paul & Tacoma Lumber Co., Division of St. Regis Paper Co. have retired from active service since Dec. 31, 1959, but will continue to be available to the company as consultants:

Everett G. Griggs II, president of St. Paul & Tacoma, and a director of St. Regis; G. Corydon Wagner, vice-president and general manager of manufacturing and sales of St. Paul & Tacoma; and W. Hilding Lindberg, vice-president of St. Paul & Tacoma and general manager of the Forestry and Logging Department of St. Regis in the Tacoma area. All have played leading roles in the operation of St. Paul & Tacoma for many years and in the development of that company to its present leading position in lumber and plywood.

Jack M. Lamb has been appointed general manager for Tacoma area operations of St. Regis, with headquarters at 1019 Pacific Ave., Tacoma, Wash. In this position, he will have direct responsibility for all operations in the Tacoma area, including logging, plywood and pulp and paper, as well as the sawmill, including the retail yard. He will report to Benton R. Cancell, executive vice-president—operations.

S. Kepple Pratt, general superintendent of pulp and paper operations at the Tacoma mill, has been named resident manager, succeeding Mr. Lamb. Mr. Pratt joined St. Regis in November, 1951, at the Jacksonville, Fla., mill as assistant to the chief engineer.

Charles L. Morey has been appointed resident manager of the St. Paul & Tacoma Division operations, including both lumber and plywood. Mr. Morey had been manager of the lumber operations of the Columbia City Division of Crown Zellerbach Corp. from 1956 until the present time.

Robert L. Martin has been named manager of the Forestry and Logging Department in the Tacoma area. Mr. Martin joined St. Paul & Tacoma Lumber Co. in June, 1951, and served as logging manager.

Arkell and Smiths

Six-Color Letterpress

Arkell and Smiths of Hudson Falls, N. Y., flexible packaging manufacturers specializing in letterpress printing, has just installed another six-color, high speed, metal plate letterpress.

The Hubinger Co.

Appointment

L. O. (Lou) Carlisle is the new manager of Corrugating Starch Sales for The Hubinger Co. of Keokuk, Iowa.

Mr. Carlisle has been prominent in the corrugating field for many years and is well known in the industry. In his new capacity he will continue to make his headquarters in Chicago, and work directly with boxboard manufacturers in the Middle West.

Standard Packaging Corp.

Appointment

Bruce W. Synder has been appointed to represent the Missisquoi Specialty Board Division, Standard Packaging Corp., in the Western territory.

Missisquoi Specialty Board Division, Standard Packaging Corp., maintains offices at 1200 W. Fullerton Ave., Chicago, Ill. Mr. Snyder will make his headquarters at that address after he finishes a tour of duty at the Missisquoi mill in Sheldon Springs, Vt.

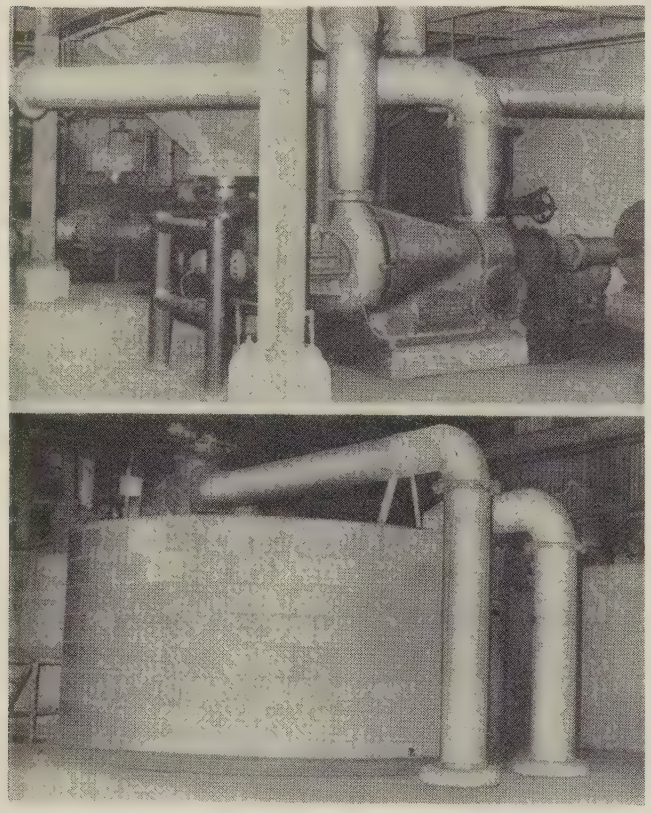
Stone Container Corp.

Expansion

Completion of an $800,000 expansion and improvement program at Stone Container Corp.'s boxboard mills at Mobile, Ala., and Franklin, Ohio, has been announced by Marvin N. Stone, executive vice-president.

The Mobile mill has broadened its boxboard line, improved quality finish and printability characteristics, and increased capacity through major redesign of its papermaking machine.

Both the Mobile and the Franklin mills have installed complete new screening systems of the Selectifier type to assure uniformly high quality stock. Various other new equipment also has been added at both mills for greater efficiency.



The Hydrafiner at the Mobile mill of Stone Container Corp.

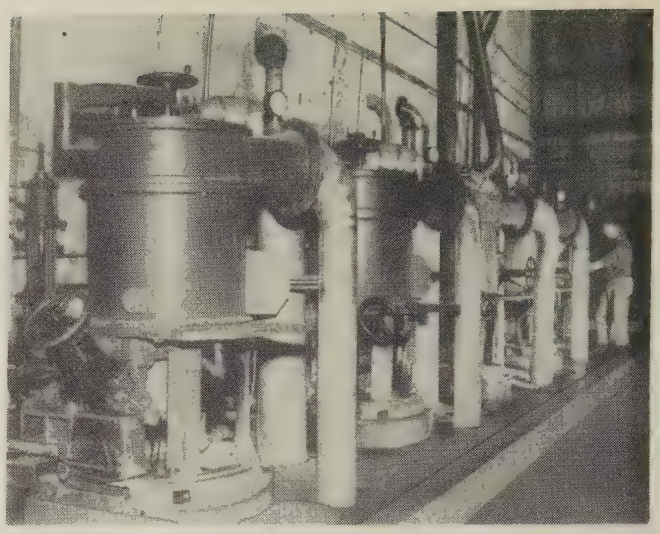
The Mobile paper machine has been enlarged from seven to eight cylinders, permitting production of heavier grades of board. The machine also has been converted so as to extract water from the pulp by additional suction equipment. The use of suction, which gives boxboards greater stiffness and smooth finish, has been achieved with an added suction drum roll and suction presses.

Along with these changes, the paper machine has undergone major redesign and rebuilding, with the wet-end flow reversed from its original direction.

With these improvements, the Mobile mill can produce boxboards ranging from 16 to 53 point and all grades from plain chipboard through patent coated as well as specialty boards, including boards for frozen foods, Stone points out.

The eight new (Black-Clawson) Selectifier screens, one for each paper machine cylinder, remove impurities from stock more efficiently through centrifugal action.

All stock entering the machine, both for filler and liner, now is processed by modern Hydrapulpers, with the installation of the filler unit (Shartle Bros.).



Four of seven new Selectifier screens at the Stone Container Corp. Franklin, Ohio, boxboard mill

Completing improvements of basic equipment, the Mobile mill has installed new pulp storage chests and a Hydrafiner (Shartle Bros.) for top liner stock, as well as other machines.

A new building has been built to house stock preparation operations.

The Stone Container mill at Franklin, which produces all grades of folding and set-up boxboard grades from 16 to 60 point, has installed a new battery of seven Selectifier screens (also Black-Clawson) for its seven-cylinder machine.

The Franklin mills also has installed a new sheet cutter (Black-Clawson), a two-knife type designed for high precision in slitting and cutting sheets for boxes. New equipment at this mill also includes new equipment for more efficient water circulation. Most of the papermaking operations at both the Mobile and Franklin mills are controlled automatically and precisely at central push-button panels. The just-completed phase of improvements at the two mills was begun in early 1959.

The mills, each with about 100 tons daily capacity, supply boxmakers over wide areas, besides certain of the company's own box-making divisions. A ten-state territory is covered by the Mobile mill, which also exports to all continents in the world. The Franklin mill markets mainly in the mid-continent territory.

Russell M. Mather of Franklin is general manager for the two mills and J. R. Boykin is resident manager at Mobile.

The company also owns a containerboard mill at Coshocton, Ohio, manufacturing semichemical corrugating medium, as well as eight box-making divisions.

Educational Institutions

Corn Industries Research Foundation, Inc.

Greenwall Elected President

Corn Industries Research Foundation, Inc., recently has announced the election of Frank K. Greenwall as president. Mr. Greenwall is chairman of the board of the National Starch and Chemical Corp., New York. He succeeds William T. Brady, president of Corn Products Co., New York, who continues as chairman of the executive

Frank K. Greenwall

committee of the Foundation. Mr. Brady and A. E. Staley, Jr., chairman of the board of A. E. Staley Manufacturing Co., Decatur, Ill., were elected vice-presidents of the foundation.

The Foundation sponsors a continuing basic-research program, now in its 27th year, in laboratories of universities, government and private research institutions.

Industry Suppliers

American Cyanamid Co.

Appointments

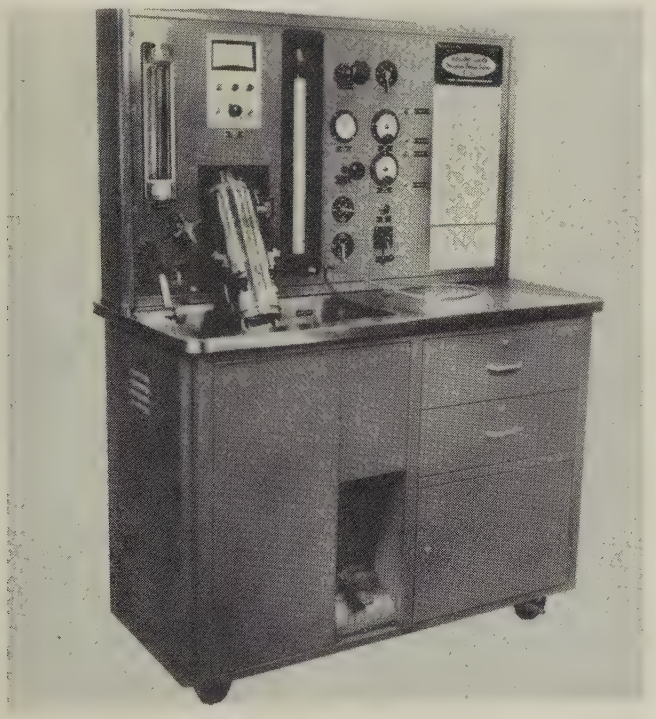
T. F. Cooke has been appointed director of the chemical research department and Robert S. Long, commercial development manager for the Organic Chemicals Division American Cyanamid Co.

Aircraft Porous Media, Inc.

Ultrasonic Filter Cleaner

Used filter elements can now be cleaned to their original differential pressure and dirt-holding capacities by means of the Pall-Cavitron HIPS equipment. The unit is a joint development of the Pall Corp., Glen Cove, N. Y., and Cavitron Equipment Corp., Long Island City, N. Y.

HIPS, HyperIntense Proximal Scanning places a hyperintense field over a small portion of the surface of the filter



Pall-Cavitron HIPS Filter Element Cleaner

at one time. The filter element is rotated through this hyper intense proximal field until the entire surface of the element is cleaned. Particles are flushed away continuously as they are loosened. It takes less than 10 minutes to clean most filter elements to a "like-new" condition.

Literature on Pall-Cavitron HIPS may be obtained from Aircraft Porous Media, Inc., a subsidiary of Pall Corp., 30 Sea Cliff Ave., Glen Cove, N. Y.

American-Marietta Co.

Appointments

A. W. Hendry, General Sales Manager for the Adhesive, Resin & Chemical Division of the American-Marietta Co., Seattle, Wash., announced that Robert L. Thomsen assumed the new position of director of marketing analysis on Jan. 1, 1960. Mr. Thomsen has been a sales representative with the company for over 10 years.

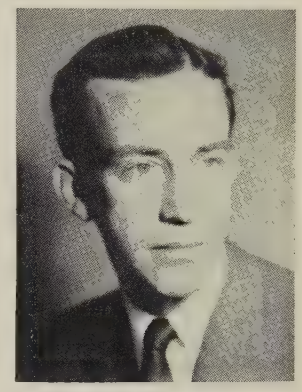
Bayard L. Carlson, Seattle, filled the new position of product manager, paper industry on January 1. Mr. Carlson, who has been with American-Marietta for over four years as a sales representative, will direct the division's sales of products manufactured for the pulp and paper industry in the Western U. S. and Canada.

American-Marietta manufactures adhesives and resins for wet strength papers, pulp molding, specialty papers, plywood, composition boards, wood laminates, mineral wool, and foundry cores and shell molds. Recently, the company announced a major break-through in the field of epoxy molding compounds for the electronic industries and missile manufacturers.

American SF Products, Inc.

Appointment

The appointment of Karl F. Gothner to succeed Arne Hallencreutz as president of American SF Products, Inc., was recently announced by Mr. Hallencreutz, who has been named vice-president in charge of international operations of the New York City company's parent firm, AB Svenska Flaktfabriken, Stockholm.



Karl F. Gothner

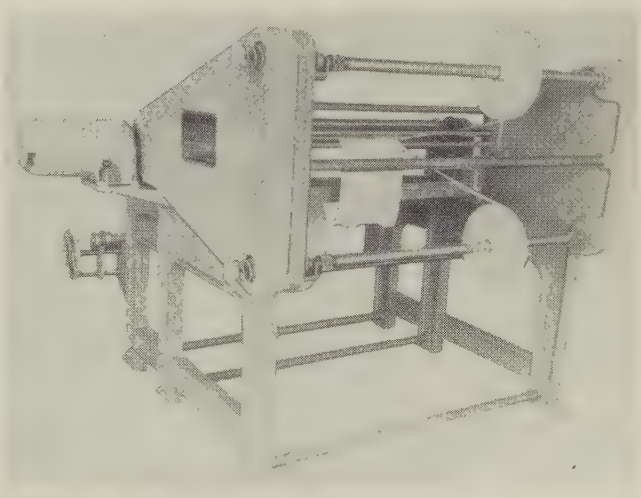
American SF Products supplies a large line of air handling and drying equipment to the industrial processing industries. Mr. Gothner has been associated with the pulp and paper industry in this country since 1947.

Appleton Machine Co.

Slitter Rewinder Model CDH-40

A duplex shear-type rewinder (Model DCH-40) manufactured by the Doven Division of Appleton Machine Co. is now available for paper, board, vinyl plastics, heavy duck, coated and rubberized fabrics up to 40 gage.

The unit will handle up to a 90-in. web and can be equipped



Slitter rewinder Model CDH-40

with razor blade or score type slitters (as well as the standard shear type slitters).

Outstanding features of this unit include a patented principle permitting each rewound roll to operate independently after slitting, thereby compensating for caliper variation and insuring uniform density. Standard models include: edge guides and tension control and either a 4-speed, quick change motor drive or Reliance variable speed drive.

Appointment

Otto J. Korth has been appointed sales engineer for Appleton. He was formerly employed as a sales representative with the Technical Papers Division of Kimberly-Clark Corp., and prior to that, he was a sales representative with Brebner Machinery Corp., Green Bay, Wis.

Married and the father of three, Mr. Korth now makes his home in Neenah, Wis.

Bailey Meter Co.

Pulp Freeness Measurement

Continuous measurement of pulp freeness, heretofore determined only through laboratory tests, is now possible with a new device developed jointly by Kimberly-Clark Corp. and Bailey Meter Co. Known as the Bailey Continuous Freeness Recorder, it may also incorporate automatic control to maintain freeness at a predetermined value.

Based on a simple but sound operation principle, the device has proved accurate and relatively maintenance free during the six-month operational period. During that time it has been successfully applied to four different types of pulp over ranges from 150 to 600 ml. freeness. Since freeness varies with consistency, the consistency of the stock sample was maintained within close limits in all cases.

During the testing period, the sample was taken from the output of the final refiner. However, its use is not necessarily limited to this application. For convenience, the continuous freeness recorder is calibrated in accordance with the Canadian freeness tester. Bailey Meter Co., Cleveland, Ohio, will manufacture and market this instrument in 1960.

B-I-F Industries, Inc.

Pump-Tank for Chemical Feeding

B-I-F Industries, Inc., of Providence, R. I., announced a new bulletin describing a low cost Proportioneers Pump-Tank Combo for the accurate and efficient feeding of chemical solutions, and for economical boiler water treatment.

For your free copy of Bulletin Ref. No. 1800.20-1, write to B-I-F Industries, Inc., 345 Harris Ave., Providence 1, R. I.

Concentric and Flat Leaf Vacuum Filters

Two vacuum filter styles for the efficient filtration of industrial process water where a highly polished water is required are featured in a new bulletin issued by Proportioneers Division of B-I-F Industries, Inc., manufacturers of process instrumentation, equipment and systems for positive control of materials in motion. The filters, Model VFL with Flat Leaf Filter Elements, and Model VFC with Concentric Leaf Filter Elements, are excellent for filtering atomic energy cooling water, photographic laboratory water, for filtration ahead of de-ionizers, etc.

For a free copy of Bulletin Ref. No. 1860.20-2, write to B-I-F Industries, Inc., 345 Harris Ave., Providence 1, R. I.

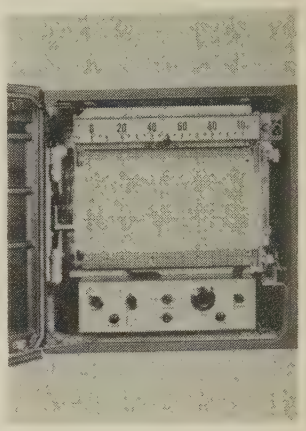
Beloit Iron Works

British Made Beloit Machinery

Paper machinery designed by Beloit Iron Works may soon be built in England, according to Harry C. Moore, president of the Beloit, Wis., firm. Negotiations are in process with The Walmsley (Bury) Group, Ltd., Lancashire, England, for an agreement of patent licensing and concurrently for the purchase of a minority interest in the English concern.

The Bristol Co.

Dynamaster Laboratory Recorder



Dynamaster laboratory recorder

The Bristol Co. is offering a new laboratory model of Bristol's Dynamaster potentiometer recorder. Basically, it is the well-known, wide-strip recording instrument especially adapted to laboratory requirements. The new multipurpose recorder lends itself readily to measuring such variables as pressure, temperature, motion, flow, density, pH, and electric power.

Special input signal selection switches and span adjustments provide maximum flexibility. The four-position input selector switch provides for millivolt, volt, microampere, or milliampere input. The five-position span selector offers ranges 0 to 2, 0 to 5, 0 to 10, 0 to 25, and 0 to 50. An alternate span continuously adjustable from 0 to 2 to 0 to 50 is available.

Subminiature Pressure Switch

A subminiature, adjustable pressure switch offered by Bristol exceeds the requirements of MIL-E-005272B for performance up to 200 p.s.i. under vibration, shock, and acceleration test conditions.

Midget pressure switch

The volume of the new pressure switch is less than 1 cu. in. and weight is only slightly over 1 oz. A Ni-Span C pressure capsule and a snap-action switch are contained in an all stainless steel housing. The pressure-setting adjustment is simple, and the setting is positive, even under severe shock and vibration conditions.

Pressure ranges and other information are available in a new Bristol Bulletin AV2015.

The Borden Chemical Co.

$4 Million PVC Plant

Construction by Borden's $4 million polyvinyl chloride plant in Illiopolis, Ill., with a total capacity of 40 million

pounds, has been announced by A. R. Marusi, the president.

The new plant will be located next to the company's existing manufacturing facilities in Illiopolis. A 20-acre tract of land has already been purchased and engineering for the project is nearing completion.

The plant will produce the company's full line of polyvinyl chloride and copolymer products, including those for the vinyl flooring industry, the record industry, solution coatings and extrusion grades, and specialty resins. Completed plant facilities will include raw material storage, polymerization reaction, blending, drying, and compounding equipment.

Borden Chemical also completed late last year a second expansion of its polyvinyl chloride production facilities at Leominster, Mass. Capacity at that location is now set at 40 million pounds.

Cochrane Corp.

Demineralizer Bulletin

A 4-page bulletin on a new line of standardized "Uni-Pac" packaged, mixed bed demineralizers, designed specially for process water applications, is now available from Cochrane Corp. Size of the new "M" Series, mixed bed design ranges up to 13,200 g.p.h.

The publication contains information on the use of demineralization process eliminating variables in water and their effects on product quality control.

Copies of the new publication, No. 5819, may be obtained from the manufacturer, 17th St. below Allegheny Ave., Philadelphia 32, Pa.

Continental Can Co.

Appointments

Robert J. Murphy has been named manager of the Teterboro, N. J. corrugated box plant, and David G. Roggenkemper appointed manager of the new Carteret fiber drum plant in that state, it was announced by C. U. Harvey, Eastern District general manager of the Fibre Drum and Corrugated Box Division of Continental Can Co.

Crane Co.

Purchase of National-U. S. Radiator Corp. and Swartout Co.

Crane has entered into an agreement to acquire the operating assets of National-U. S. Radiator for over $15 million in cash for plants, equipment and inventory.

At the same time Thomas M. Evans, chairman of Crane Co., announced the acquisition of the Autronic Division of The Swartout Co. of Cleveland, Ohio, maker of electronic controls.

Dempster Brothers

Compaction Trailers

A new hydraulic compaction trailer, which compacts paper plant waste, wood chips and refuse to a fraction of its former volume, has been announced by Dempster Brothers or Knoxville, Tenn., manufacturer of the well-known Dempster-Dumpster Systems. Said to be the world's largest hydraulic packer, the trailer was designed for use by manufacturers who generate huge quantities of waste, or who face the problem of long hauls to refuse disposal areas.

Available in two sizes, Model DB-42 will hydraulically pack-in approximately 160 cu- yd. of loose refuse, and Model DB-53 will hold up to approximately 210 cu. yd. The compacting operation of the trailer is hydraulic—there are no chains, sprockets, or cables, and it can be handled on any standard fifth wheel tractor or used with a tandem tractor.

For complete information on the new Dempster compaction trailer, write Dept. CT-27, Dempster Brothers, Knoxville, Tenn.

Compaction Trailer

Diamond Alkali Co.

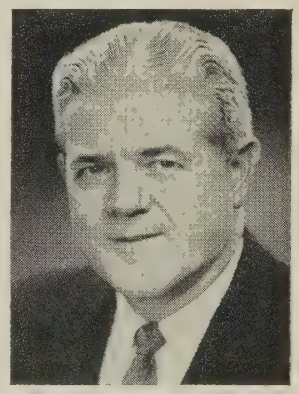
New Weed Killer

A new herbicide, dimethyl tetrachloroterephthalate, called DaCTHAL controls crabgrass and other noxious annual weeds which are a menace to beautiful lawns. Applied early in the spring, the chemical prevents the germination and growth of crabgrass. It does not cause grasses to "brown" nor does it leave the usual "burnt spots."

DaCTHAL is described by the company spokesmen as being nontoxic and nonpoisonous. Available as a dry formulation for easy application in conventional spreaders, it will be offered to the consumer in various test markets during the coming year by Swift and Co. under their brand name, RID.

The Dobeckmun Co.

Appointments



Nicholas R. Sheehan

Nicholas R. Sheehan has been promoted to manager of the industrial sales division of The Dobeckmun Co., A Division of The Dow Chemical Co., it has been announced by Robert S. Jones, general sales manager.

In his new position, Mr. Sheehan will have complete responsibility for the sale of the company's industrial products, including barrier materials, electrical insulation tapes, laminated card stock and tape, and Metalflake decorative metallic chips.

Dodge Fibers Corp.

Fluorglas Endless Belt

A new Teflon-coated, glass endless belt to conquer the problems of heat and sticky surfaces has been introduced by Dodge Fibers Corp. of Hoosick Falls, N. Y. Called Fluorglas, the belt is chemical and solvent resistant. It has a wide temperature range (−400 to +600°F.) with antiadhesive and antifriction properties.

Fluorglas is particularly outstanding where sanitation and ease of release are important.

Fluorglas endless belts are dimensionally stable, and will not

stretch or shrink. The belts are available in a variety of widths and thicknesses and are sold nationally through industrial distributors.

Dow Chemical Co.

Appointments

M. W. Zembal, a customer service chemist, has been transferred to Freeport, Tex., to take charge of the CTS-South operation. While his primary duties will be to expedite product development out of the Dow Texas Division research laboratories at Freeport, he will also handle CTS technical service problems in the South.

Roy C. Simon, who has been in charge of CTS-West operations for the past 5 years, has been promoted to section head. He will continue as head of CTS-West, headquartered at the Western Division's Pittsburg, Calif., plant.

Ralph C. Hand, who was appointed section head of building products several months ago, has been assigned as section head of a new group, the plastics and rubber section. This section will cover CTS monomer and epoxy resin activities not specifically located in other sections.

Succeeding Hand as section head of building products is A. A. Hill. Mr. Hill advances from customer service chemist, the post he has held to past two years.

Stanley F. Roth, customer service chemist, has been promoted to section head in charge of the packaging section. He replaces F. R. Lehman who has been assigned to a project position as plastics sales supervisor with Dow Chemical Co. (U. K.) Ltd. Mr. Lehman will be on leave of absence from CTS for about 2 years and will be located in England.

General Dyestuff Co.—Division General Aniline & Film Corp.

IGEPAL Surfactants

A new 22-page booklet, describing the applications of IGEPAL surfactants in the manufacture of pulp and paper has been announced by General Dyestuff Co.

The booklet lists four IGEPAL surface-active agents and describes their uses in various phases of pulp manufacture, in paper and paperboard manufacture, in the washing of woolen paper-machine felts, and in the deinking of paper and the stripping and cleaning of rag stock.

A copy of Bulletin AP-97 may be obtained by writing to General Dyestuff Co., Division of General Aniline & Film Corp., 435 Hudson St., New York 14, N. Y.

Appointments

The following appointments and changes affecting Antara Chemicals' Field Sales Force were announced by Thomas R. Moore, field sales manager, Antara Chemicals, a sales division of Dyestuff and Chemical Division.

Alfred W. Purdy, until now a sales engineer in the company's Philadelphia office, has been promoted to eastern regional manager.

John P. Miller replaces Mr. Purdy as a sales engineer for the Philadelphia area and Joseph A. Czerwinski has moved into Mr. Miller's previous position of sales engineer in the St. Louis area.

Two additional changes concern William C. Brunson and Eugene M. Kennedy.

Mr. Brunson is being transferred from Atlanta, Ga., to the company's New Jersey territory. Replacing him in Atlanta is Mr. Kennedy who has been appointed a sales engineer for that area.

Reorganize Pigment Sales

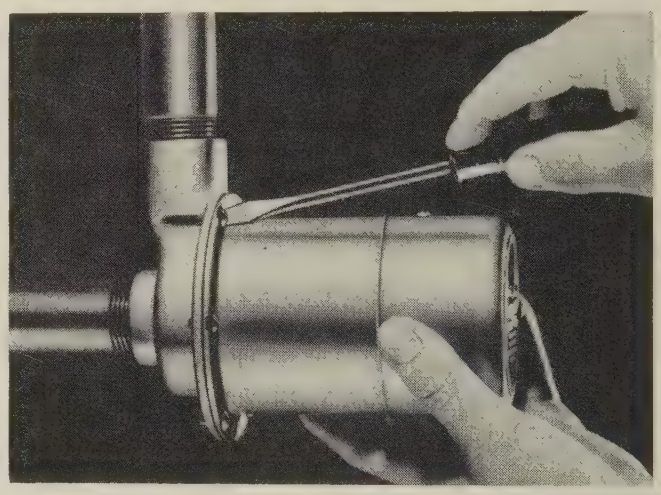
In line with the increasing emphasis and importance of pigment manufacture, research, sales and applications, the Dyestuff and Chemical Division, announces the establishment of a new and separate Pigment Department.

Robert E. Brouillard, who was recently appointed sales manager—pigments, announced the following new appointments: Leon Katz, product manager—pigments; Maurice L. McCord, western regional manager; John D. Shaw, eastern regional manager; Theodore B. Smock, midwestern regional manager; Emil A. Wich, manager technical services.

Fostoria Corp.

Leak-Proof Pump

A new low-cost, compact, leakproof pump for commercial and industrial use has been developed by Dynapump Division of Fostoria Corp. Known as Dynapump Model 420D, the new unit weighs less than 7 lb., yet is capable of pumping over 800 gal per hr. It will produce heads up to 12 ft. Constructed entirely of corrosion-resistant material, the new leakproof pump offers all of the advantages of canned pumps. Since rotor, shaft, and impeller form a single assembly enclosed or "canned" in a stainless steel cylinder, there is no stuffing box or mechanical seal to permit leakage. The pumped fluid itself circulates in the rotor chamber and acts as bearing lubricant and motor coolant. No external lubrication is ever required.



"Canned," leak-proof pump

Dynapump Model 420D is suitable for pressures to 150 p.s.i. and temperatures to 220°F. It is available for operation of either 115 or 220 volts, single-phase, 50 or 60 cycles. Automatic overload cutout protection is provided. The pump can be used on a wide variety of solvents, refrigerants, and other "difficult" fluids. For more information, write Dynapump Division, Fostoria Corp., P. O. Box 35-3, Huntingdon Valley, Pa.

Two-Stage High-Head "Canned" Pumps

Bulletin 1080 describes a new series of two-stage, high-head leakproof "canned" pumps for heads up to 600 ft., temperatures to 850°F., and pressures to 3500 p.s.i. For free copy, write Chempump Division, Fostoria Corp., P. O. Box 35-2, Huntingdon Valley, Pa.

General Aniline & Film Corp.

L. Byron Cherry has been appointed general manager of the Ozalid Division of General Aniline & Film Corp.

He replaces Walter A. Hensel, formerly general manager of the Ozalid Division, who recently resigned.

Ozalid is a producer of diazo sensitized materials and whiteprint duplicating machines with headquarters in Johnson City, N. Y.

General Electric

Steam Turbine Generators for Paper Firms

Two paper firms with plants in the Southern United States have placed orders with General Electric Co.'s Medium Steam Turbine, Generator and Gear Department for industrial steam turbine-generator units totaling 40,000 kw. in capacity.

A 20,000-kw. unit will be installed by the Rome Kraft Co. in Rome, Ga. Scheduled for delivery in early 1960, this unit will be of the automatic extraction design.

International Paper Co.'s Southern Kraft Division operation at Bastrop, La., will utilize a 20,000 kw. steam turbine-generator unit employing high temperatures and pressures. Shipment of International Paper's new powermaker is scheduled for mid-1960.

Hughes W. Ogilvie has been named manager—marketing for G.E. medium steam turbine, generator and gear department.

New Speed Recorder

Bulletin GET-2741-3A (four pages) discusses application, features, principles of operation, and specifications of G.E.'s Type HF multirange, strip-chart speed recorders. Material-processing applications related to the paper, steel, textile, rubber, and other industries are described. The bulletin includes application diagrams, a schematic of the recorder, and a description of accessories available. General Electric Co., Schenectady 5, N. Y.

Round Chart Recorder-Controller

A round-chart recorder featuring accuracies of ±0.25% is now avaialable from G.E.

Most of the recorder's components are interchangeable with those of existing G.E. strip-chart models. This will assure easy maintenance and quick accessibility of parts.

Minimum accurate scale span for the recorder—a null-balance, potentiometer-type design—is 1 mv. d.c. Response times available are 4, 10, and 24 sec. full scale.

A zener diode, which eliminates use of a dry cell or standard-cell power supply, offers a constant-voltage reference accurate to ±0.05%. Temperature coefficient is 0.001% per °C.

Halogen Leak Detectors

Leak Testing of Tanks, Piping And Other Enclosures, GET-2936, six pages, gives detailed instructions on use of halogen leak detectors for finding leaks in enclosures that can be pressurized. Applications discussed include aircraft and missile fuel and hydraulic systems, dairy equipment, steam boilers, valves, piping, transformers, air-conditioning and refrigeration equipment, and others. Includes discussion of system preparation, testing procedures, quantitative measurement techniques, and calibration. General Electric Co., Schenectady 5, N. Y.

Vacuum Leak Detector

Locating Leaks in Vacuum Systems, 4-page Bulletin, GET-2935, provides detailed information on how to use halogen-sensitive, vacuum leak detectors in the laboratory and in production to locate leaks down to 1×10^{-6} cc. per sec. Typical applications include vacuum furnaces and metalizers, production testing of refrigeration units before charging with refrigerant, and for any other evacuated enclosures where vacuum is 1 to 500 μ or more. Includes description of the General Electric Type H-4 leak detector, installation and operation procedures, and techniques for locating leaks. General Electric Co., Schenectady 5, N. Y.

"On" Time Units

Process Timers for Controlling Repeating Cycles, 4-page Bulletin, GEZ-2985, describes G.E. Type TSA-14 adjustable "on" time units. Includes description of features and application, ratings, dimensions, prices, and ordering directions. General Electric Co., Schenectady 5, N. Y.

Conversion Units for Electrostatic Precipitators

A new silicon rectifier conversion unit has been developed for use in high voltage d.c. power supplies on electrostatic precipitators that collect flyash and dust particles in industrial plants and electric utility generating stations.

Similar in size and shape to high-voltage vacuum rectifier tubes, the new units consist of silicon rectifier diodes which are immersed in oil and enclosed in an insulating cylinder.

The silicon rectifier conversion units are available for use with rectifier transformers rated up to 75,000 v. r.m.s., and up to 45 kv-amp in full wave bridge rectifier circuits. General Electric Co., Schenectady 5, N. Y.

Appointment

George E. Shepherd has been appointed Manager in charge of a newly established sales district for General Electric's Silicone Products Department. Designated as the New England District, this area has responsibility for the sale of General Electric silicone products in Massachusetts, Rhode Island, Maine, New Hampshine, Vermont, Connecticut, and Upstate New York. District Headquarters will be located at 145 North Beacon St., Boston 35, Mass.

W. L. Gore & Associates, Inc.

Etchant Simplifies Bonding of Teflon

Tetra-Etch, an active form of sodium in solution, bonds Teflon to itself and to other materials.

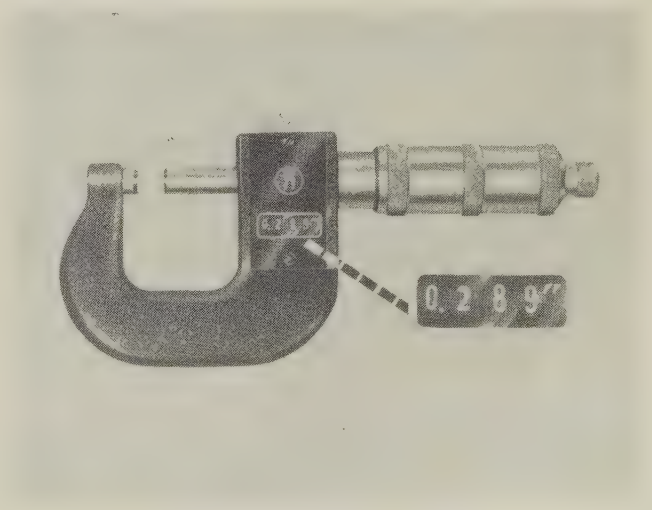
Developed by W. L. Gore & Associates, Inc., Newark, Del., Tetra-Etch reacts with Teflon to form a carbonaceous film on the treated surface. This film then serves as a means of anchoring adhesives to the Teflon. The compound has proved compatible with a variety of adhesives, including epoxides, phenol formaldehydes, and most of the rubber and silicone types.

Treatment time ranges from about 5 sec. to 1 min.(heating the Teflon before treatment increases the etching rate). Resulting peel strength with a typical epoxy adhesive run from about 17 lb. per in. on smooth Teflon to 35 lb. per in. on corrugated ribbon.

Glass Laboratories, Inc.

Direct heading Micrometer

A new micrometer that dials visual readings automatically has just been introduced by Glass Laboratories, Inc., 863 65th St., Brooklyn 20, N. Y. Called the D. R. (Direct Reading) Micrometer, it eliminates human error by providing automatic and exact dial readings from zero to 1 in.



Direct reading micrometer

The D. R. Micrometer sells for $35; units providing readings from 1 to 2 in. sell for $38; accessory stands sell for $10.

Complete information and literature may be obtained by writing the company.

The Glidden Co.

Appointment

Walter H. Vastrick has been appointed to the sales staff of The Glidden Co.'s Chemicals-Pigments-Metals Division in Baltimore.

Mr. Vastrick's appointment is the result of the Chemicals-Pigments-Metals Division's stepped-up marketing activities and expansion of its sales force in order to better serve the growing demand for titanium dioxide and other products of the division.

A 1948 graduate with a Master of Science degree from the University of Michigan, Mr. Vastrick was technical director of the Hawthorne Paper Co. prior to joining Glidden. Before that he had filled several supervisory posts with the Allied Paper Corp. and had been associated for eight years with the St. Regis Paper Co. as assistant production manager at its Kalamazoo, Mich., plant.

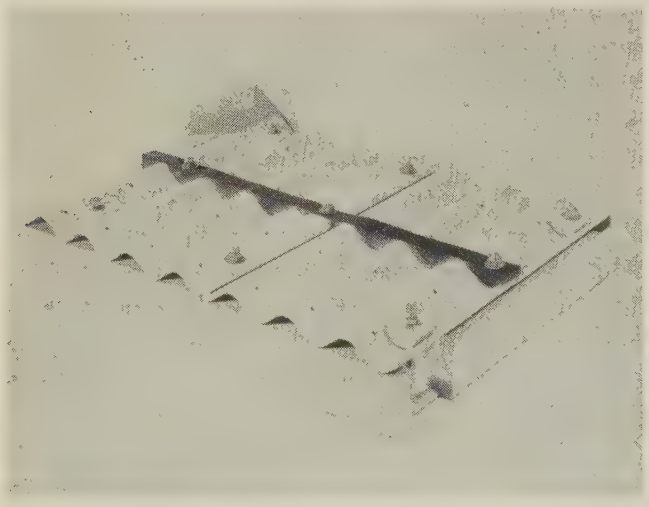
Mr. Vastrick will be headquartered in Kalamazoo, Mich.

Graver Water Conditioning Co.

Noncorrosive Underdrain

A patented, noncorrosive underdrain design for rapid sand filters, has been introduced by Graver Water Conditioning Co. Corru-Drain is made of corrugated asbestos-cement sheets with the corrugations forming the laterals. It is designed for applications where large flows call for rectangular or square, concrete gravity filters.

Corru-Drain has many advantages: its light weight, toughness, ease of shipping and handling, and simplicity of installation. Its design also provides for optimum backwashing distribution because of the method of orifice arrangement. It can be installed easily in new filters and is readily adaptable for replacing underdrains in existing filters with a minimum of structural changes.



Model of Corru-Drain

For further information, contact R. S. Lewis, Manager, Sales Promotion, Graver Water Conditioning Co., 216 W. 14th St., New York 11, N. Y.

Hercules Powder Co.

Appointments

Four executive appointments in the new International Department of Hercules Powder Co. have been announced by Henry A. Thouron, the department's general manager.

The new appointments are:

William L. Cahall, director of sales.

Warren F. Beasley, director of development and operations, Western Hemisphere.

Harvey J. Taufen, director of development and operations, Far East.

Henry Reeves, Jr., director of development and operations, Europe.

The newly created International Department encompasses the work of the company's Export Department, and has equal status with Hercules' six operating departments. The International Department is charged with the responsibilities for foreign sales, foreign investments, and the management of foreign subsidiaries and affiliates.

Robert W. Cairns, director of research for Hercules, has been elected a member of the board of directors. Mr. Cairns has been director of research since 1955. He began his career with Hercules in 1934 as a research chemist.

In 1954 he was Deputy Assistant Secretary of Defense (R & D) under the late Donald A. Quarles, the first Assistant Secretary (R & D). He is now a defense consultant and chairman of the General Sciences Advisory Panel and a member of the Defense Science Board. He is president of the Industrial Research Institute, and an active participant in several national research management groups.

In 1941 he was named director of the Hercules Research Center, near Wilmington, Del.

Philip B. Stull retired in December from Hercules Powder Co. upon completion of 33 years as an executive with the company, including 27 years as a member of Hercules board of directors.

Mr. Stull resigned as a vice-president, member of the board of directors, and of the executive committee of Hercules at the end of last year. Throughout 1959, he has been on special assignment.

Hooker Chemical Co.

L. A. Offices Move

The combined Los Angeles sales offices of both the Durez Plastics and Western Chemical Divisions of Hooker Chemical Corp. have been moved to 6277 E. Slauson Ave., Los Angeles 2, Calif.

These offices are to consolidated with modern warehouse facilities for the company's products in the new warehouse of Interamerican Warehouse Corp. at this location, where all company stock for the area will be stored henceforth.

Johns-Manville

Thermal Insulation Catalog

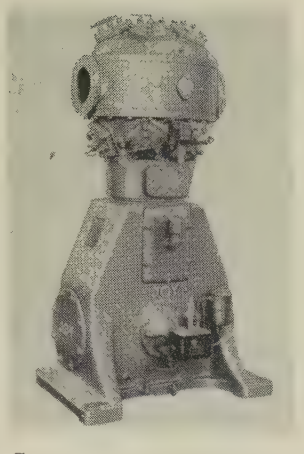
Thermal insulations for all types of commercial and industrial requirements, in applications ranging from −400 to 3000°F., are described in a new 54-page catalog published by Johns-Manville.

Entitled "Insulation Product Information" (A.I.A. File No. 37-D), it contains six complete sections, each devoted to a specialized group of Johns-Manville thermal insulations. These include industrial and high temperature; plumbing, heating, and air conditioning; refrigeration; insulating firebrick and refractories; finishes and weatherproofing materials; and miscellaneous insulations, including asbestos papers, millboard, felts, blankets, and similar products. Individual sections are thumbtabbed for easy reference.

Copies of this catalog will be supplied through local offices upon request for Catalog IN-244A. Requests should be sent to Johns-Manville Sales Corp., 22 East 40th St., New York 16, N. Y.

Joy Manufacturing Co.

Vertical Single-Stage Compressor



Compressor model WG-9H

Joy announces the addition of a new, vertical, single-stage compressor to its line of heavy duty air, gas boosting, and oil-free compressors. The new machine, WG-9H, has piston displacements from 633 to 1630 cu. ft. per min. with maximum pressures to 125 p.s.i. and horsepower ratings to 150.

The WG-9H now gives Joy three basic single-stage compressor models, increasing the number of sizes to 20 which include 5, 7, and 9-in. piston strokes.

For further information write for Bulletin GG-5H, Joy Manufacturing Co., Henry W. Oliver Building, Pittsburgh 22, Pa.

R. G. LeTourneau, Inc.

Three-Wheeled Fork-Lift

A three-wheeled, fork-lift truck is powered to lift and carry nine average American cars.

Well suited for handling materials ranging from steel products to logs to prestressed concrete, the new stackers will prove particularly valuable in unpaved work areas where loads range from 10 to 17 tons.

First units off the production line probably will go to the logging industry, helping to modernize medium-size mill operations. Others are expected to go to heavy manufacturing and construction operations.

The three-wheeled fork-lift shown undergoing tests on the R. G. LeTourneau, Inc., proving grounds at Longview, Tex.

The new machine with its 17-ton capacity is one of the largest available anywhere for general industrial work. Forks of the new "FT" machine are 5 ft. long and can hoist loads 16 ft. above the ground.

Power is supplied by a 195-hp. diesel engine, driving a.c. and d.c. generators under the hood. Simple electric switches and potentiometers govern all work functions.

For additional information write to R. G. LeTourneau, Inc., 2399 S. MacArthur, Longview, Tex.

Samuel M. Langston Co.

Annular Rings Eliminated

Annular rings in rewound rolls of paper are eliminated by a newly designed, precision-machined cutter holder and cutter now furnished on slitter and winders of Samuel M. Langston Co., Camden, N. J.

The patented supershear-cutting slitter performs without

William Emerson compares rewind of two rolls of paper

creating the familiar annular rings by slitting more accurately than has been possible. Equipped with a new type locking device, the new design can be secured tighter to the slitter shaft yet does not suffer any distortion of shape in locking up. It also can be easily moved sideways on the shaft as required.

The new cutter holders and cutter can be furnished also for existing Langston slitter and winders.

Micro Metallic Division, Pall Corp.

Porous Stainless Steel Filters

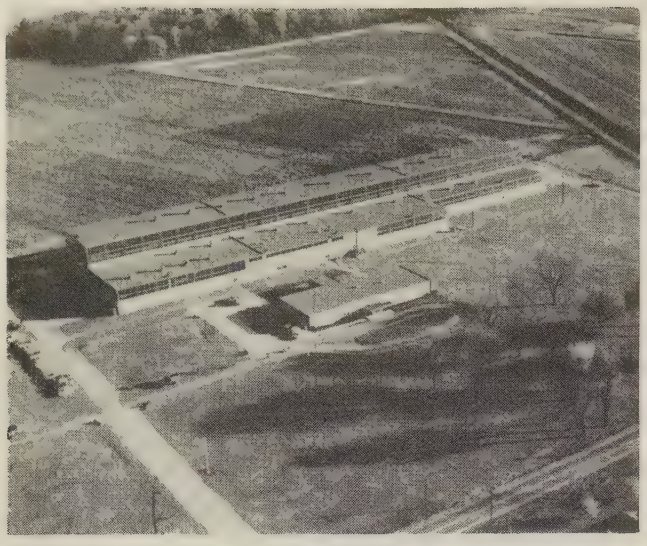
New, revised literature on porous stainless steel filters is available from Micro Metallic Division of Pall Corp., Glen Cove, N. Y. The literature includes information on properties of porous stainless steel. Full specifications are included on standard filters manufactured by the company, and a number of new filter types and sizes are presented.

The bulletin, Release M-212A, is free upon request.

Manchester Machine Co.

New Location

Manchester Machine, manufacturers of papermaking machinery, has completed the moving of its equipment from its former location in Middletown, to Monroe, Ohio. The new plant, with offices for engineering and administration,



Manchester Machine's new plant in Monroe, Ohio

will more than double the productive capacity of the old plant.

The modern machine ship and office together have 100,000 sq. ft. of space—roughly the size of two football fields. The main bay of the shop is 70 by 580 ft. and provides 35 ft. of working height beneath three overhead traveling cranes. The plant has eight overhead traveling cranes in all.

The company makes complete machines of the fourdrinier and cylinder types as well as component parts, such as suction rolls and presses, driers, reels, calenders, and winders. It is a subsidiary of Diamond National Corp.

Miles Chemical Co.

SUMSTAR, New Paper Making Chemical

A polymeric dialdehyde, an organic chemical made from starch, is believed to have many qualities which make it ideal for use in the papermaking industry.

Placed on semicommercial production by Miles Chemical Co. at its Zeeland, Mich., plant, the new chemical SUMSTAR®, a nonvolatile fine powder with extremely low acute toxidity, gives both wet and dry strength to paper. Wet strength is initially higher than that obtained with commonly used melamine-formaldehyde resins. But after 3 or 4 hours of water soaking, wet strength diminishes, desirable in industrial and household uses of papers. It also may affect favorably such characteristics as oil and grease resistance, tensile strength, elongation, stiffness, and porosity. The chemical can be used in paper sizing and as an adjunct in binders for paper coatings.

At the same time, certain derivatives such as mono-urea and di-urea, bisulfite, melamine and acrylamide adducts could have as wide a range of applications as the original product.

Miles is marketing the new colorless and odorless chemical under the trade name SUMSTAR.

Minneapolis-Honeywell Regulator Co.

Δ P/I Transmitter

A 4-page specification describes Honeywell's new ΔP/I (differential pressure-to-current) transmitter which measures differential pressure ranging from 0 to 20 in. of water to 0 to 400 in. of water, and transmits a proportional 4 to 30 ma. d.c. signal. Write for FS301-7 for detailed specification, dimensions and features.

ElectriK Tel-O-Set Recorders and Control Stations

A 4-page sheet describes Honeywell's new ElectriK Tel-O-Set recorders and recording control stations which continuously indicate and record the standard 4 to 20 ma d.c. output of any ElectriK Tel-O-Set transmitter or transducer. All of them contain an integral transistorized power supply that makes possible true two-wire transmission from field mounted devices. Controller specifications, dimensions, and features are also included. Write for Specifications FS-301-8.

Monsanto Chemical Co.

Acid Storage and Handling

Monsanto Chemical Co.'s Inorganic Chemicals Division has announced the publication of three technical bulletins covering the bulk handling and storage of sulfuric acid and oleum (I-182), chlorosulfonic acid (I-181) and muriatic acid (I-183).

The illustrated bulletins are designed to give technical assistance in setting up safe procedures in the bulk unloading, handling, and storage of the materials. Each publication covers shipments, tank car dome fittings, tank truck pipe fittings, factors to consider in determining storage tank sizes, construction materials, level indication, tank car and tank truck unloading methods, product sampling, safety factors, etc.

Copies of the technical bulletins are available free from the Inorganic Chemicals Division, Monsanto Chemical Co., 800 N. Lindbergh Blvd., St. Louis 66, Mo.

TKPP, New Detergent

Monsanto has announced publication of technical data sheets on tetrapotassium pyrophosphate, TKPP, a product which has assumed a major role in the detergent industry because it combines high solubility with outstanding water softening, emulsifying, dispersing, and deflocculation properties.

Copies of the data sheets are available free from the Inorganic Chemicals Division, Monsanto Chemical Co., 800 N. Lindbergh Blvd., St. Louis 66, Mo.

Morgan Adhesives Co.

Appointments

C. J. Lee, will represent Morgan Adhesives Co. in New York and the surrounding East Coast area. He will be Eastern regional sales manager representing Morgan Adhesives' full line of MACTAC pressure sensitive printstocks which are designed for the printer, lithographer, and silk screen processor.

Morgan Adhesives, located in Stow, Ohio, is a recently formed subsidiary of the Bemis Bro. Bag Co., of St. Louis, Mo. Burton D. Morgan, a pioneer in the field of pressure sensitive printstocks, is the president of Morgan Adhesives, which produces self-adhesive printstocks for the graphic arts industry and for package design.

C. J. Lee

Nalco Chemical Co.

Manfred W. Luthgens has been named group leader, Papermaking Chemicals Research, at Nalco Chemical Co., Chicago.

In addition to supervising research activity in current product areas, he will direct a broad research program, already underway, in developing new Nalco products for the papermaking industry.

Prior to joining Nalco, he was research group leader for West Virginia Pulp and Paper Co.

Dr. Luthgens studied Wood Chemistry at the University of Hamburg, receiving a doctorate in science in 1956, and has done considerable research work for the German Wood Research Association, and the German Institute of Wood and Cellulose Chemistry. He is a member of TAPPI.

Narmco Resins and Coatings Co.

Adhesive for Sandwich Structures and Metal Bonds

A new adhesive, adaptable to both sandwich structures and to metal-to-metal bonds is now available from Narmco Resins & Coatings Co., of this city.

Designated METLBOND 406, the new material is an unsupported, calendered "tape," at present supplied in rolls 18 in. wide. The material can be cut with ease, and trimmed to the shape of the areas to be bonded. At room temperature, the adhesive is dry, pliable, and easy to handle. At elevated temperatures, however, it momentarily softens and flows, wetting the bonding surfaces. With the continued application of heat and moderate pressure, the adhesive cures into a tough, high-strength film capable of maintaining excellent bond strengths at temperatures up to 200°F.

In metal-to-metal bonds, room temperature shear strengths are in the order of 5000 to 6000 p.s.i. In sandwich constructions, using aluminum $^1/_4$-in. cell size core material, and aluminum skin 0.020-in. thick, the room temperature climbing drum peel strength of the core-to-skin bond is 150 lb. per 3-in. width.

Descriptive data sheets are available. For additional information, address inquiries to: Narmco Resins & Coatings Co., Marketing Department, 600 Victoria St., Costa Mesa, Calif.

National Polychemicals, Inc.

Sales Activities Expansion

National Polychemicals, Inc., is expanding its sales group to handle its increased volume of business, including the sales of products manufactured by its recently formed Synthetic Resin Division.

New appointments to the sales staff are John C. Haughey, manager, Midwestern sales, and Norman W. Torgersen, New England area representative for the company.

John C. Blackwood, who joined the company early this year, has been appointed manager, Eastern sales. Francis X. O'Keefe, formerly administrative assistant, has been named sales coordinator.

National Polychemicals manufactures organic chemicals, plasticizers and synthetic resins in its multiunit plant operation in Wilmington.

Penick and Ford, Ltd., Inc.

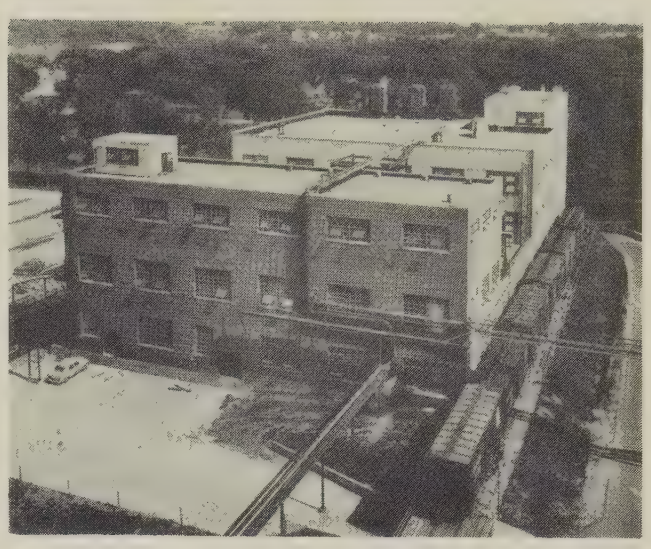
Expansion

The most modern starch derivative producing plant in the United States is now on stream. Built by Penick & Ford, Ltd., Inc., at its corn refining facility in Cedar Rapids, Iowa, the new plant was specifically designed to produce the company's expanding line of specialty starches including its Penford Gums.

This latest phase of Penick & Ford's over-all expansion will allow the company to increase its total industrial starch output by 40%.

The blender, world's largest, delivers a completely uniform batch of starch in carload lots. The big advantage of mixing starches in a blender of this size is not the amount of the batch, but the extreme uniformity it allows—a carload of starch with one bag exactly the same as the next.

Penford Gums, available commercially since 1952, are hydroxyethyl ether derivatives of cornstarch. They are



Penick & Ford, Ltd., Cedar Rapids, Iowa

used by paper manufacturers and converters in beater or furnish sizing, tub, size-press and calendar sizing, various coating applications, laminating of all types, in kraft and label stock, in board and paper, and in adhesives.

Nopco Chemical Co.

Metasap Division

R. F. McClellan, vice-president in charge of the Industrial Division of Nopco Chemical Co. announced that its subsidiary of 42 years, Metasap Chemical Co., became a Nopco division on Jan. 1, 1960.

Tom Campbell, manager of Metasap became manager of the newly-formed Metasap Division. The sales production and laboratory personnel will continue in their present capacities.

All Metasap correspondence should be directed to the present addresses at Newark, N. J.; Cedartown, Ga.; Richmond, Calif.; London, Canada; Chicago, Ill., or Boston, Mass.

Pennsalt Chemicals Corp.

Technical Center to Cost $6,000,000

Pennsalt Chemicals Corp. has concluded negotiations with Cabot, Cabot & Forbes to purchase a 50-acre site in the King of Prussia Park for construction of a Technical Center which will ultimately represent an investment of $6,000,000. This Park, located at the Valley Forge Interchange of the Pennsylvania Turnpike, is one of 14 industrial parks developed by Cabot, Cabot & Forbes along the Eastern Seaboard.

New Plant in Atlanta

Pennsalt will invest about $500,000 in a new blending, packaging, and warehousing plant at Atlanta, Ga. Scheduled to go on stream in the spring of 1960, the Atlanta plant will be the seventh unit devoted to production of Pennsalt specialties added in the past five years.

In announcing the new facility, Pennsalt President William P. Drake said:

"The Atlanta plant continues our program of emphasis on customer-oriented marketing. We have found we can give better service to our specialty customers through establishment of strategically located production units in major market areas. In addition, the new unit gives us added capacity to meet the growing demand in the South for our specialized products. With chemical specialty plants in Pennsylvania, Ohio, Ontario (Canada), Illinois, California, Texas, and now Georgia, we face 1960 well equipped to serve our customers rapidly and efficiently."

Plastic Associates

Adhesive for "Nonbondable" Teflon

A new adhesive has been developed for bonding "nonbondable" Teflon to itself and to other materials.

Designated PA-746 by the manufacturer, Plastic Associates, the new adhesive system is supplied in kit form for both laboratory and production-line applications. Each kit includes a treating agent which prepares the Teflon surface, plus a two-part bonding agent that cures in a few hours to form a high-strength adhesive joint.

With PA-746 any standard grade of Teflon or other fluorocarbon plastic may be employed, and laboratory or production personnel can fabricate the parts without special training. Since the PA-746 Teflon treatment is restricted only to those surfaces that are to be bonded the electrical or physical characteristics of the remaining Teflon surfaces are not altered by the carbonization process normally used to make Teflon "bondable."

For additional information concerning PA-746, contact Plastic Associates, 185 Mountain Rd., Laguna Beach, Calif.

OPW-Jordan

Gate Valve with Nylon Disks

A new bulletin, NP-76E, on the nylon disk gate valve No. 76, is now available from OPW-Jordan. It fully describes and illustrates the unique nylon disks which are used as seats. The aluminum body, stainless steel stem, and nylon disk seats have wide industrial application because of their resistance to a wide range of chemicals. Recommendation chart on chemical applications sent on request. The 3-in. No. 76 gate valve is suitable for pressures to 75 p.s.i. and temperatures to 200°F. Complete engineering information, specifications, and Chemical Recommendation Chart No. 76 are available from OPW-Jordan, 6013 Wiehe Rd., Cincinnati 13, Ohio.

Owens-Illinois

Appointment

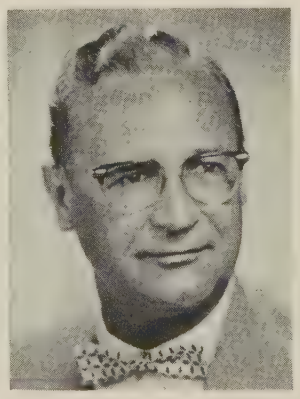
Kevin J. Solon, assistant to the vice-president and general sales manager of the Glass Container Division of Owens-Illinois, has been appointed director of product planning and marketing research for the company's Paper Products Division.

A native of Toledo, Mr. Solon joined O-I in 1931 and served for four years with O–I's Closure Service Co. In 1936 and 1937 he was a special analyst in the statistical and inventory control division of the Glass Container Division, and headed a similar operation for the former Owens-Illinois Can Co., from 1938 to 1944.

Subsequently, Mr. Solon was manager of the Glass Container Division's Sales Control Division for seven years before assuming his present duties in 1953.

One of the founders of the Toledo Sales Executives Club, Mr. Solon is also a past president of the Harvard Business School Club of Toledo, and is a member of the Northwestern Ohio Marketing Association.

George H. Olvey, of Toledo, Ohio, vice-president and sales manager of the Mill Division of Owens-Illinois, has joined the Paper Products Division of O-I as general manager of its Aurora, Ind., corrugated shipping box plant.



George H. Olvey

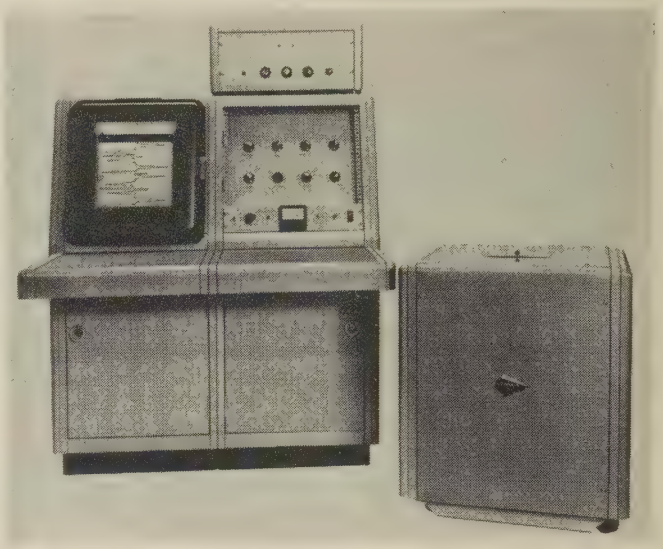
Prior to joining the Owens-Illinois Forest Products group, in 1958, Mr. Olvey was sales manager for the LaBoiteaux Paper Co. of Cincinnati.

Ridgefield Instrumentation Div., Schlumberger Well Surveying Corp.

Fluorine Analyzer

A new fluorine analyzer of liquids and solids employing nuclear magnetic resonance (NMR) techniques is announced by Ridgefield.

Designated the Model 105 Analyzer, the instrument can detect fluorine in liquids down to 3 mg. in any sample



The Model 105 fluorine analyzer

size from 0.2 to 40 cc. When the smallest sample size is used, the higher field homogeneity permits high-resolution structure analysis to be applied. Fluorine peaks which are chemically shifted more than 9 p.p.m. can be cleanly resolved.

For further information contact Ridgefield Instrumentation Div., Schlumberger Well Surveying Corp., Ridgefield, Conn.

Hydrogen and Fluorine Compound Analyzer

A 2-page data sheet available from Schlumberger Well Surveying Corp., Ridgefield Instrumentation Div., describes its line of nuclear magnetic resonance (NMR) analyzers for hydrogen and fluorine compounds.

The data sheet covers the Model 104 hydrogen analyzer, Model 105 fluorine analyzer and Model 106 hydrogen and fluorine analyzer. Specifications and typical analysis chart are included. A complete section is devoted to fluorine determinations in semimicro amounts.

Copies can be obtained from Ridgefield Instrumentation Division, Schlumberger Well Surveying Corp., Ridgefield, Conn.

J. O. Ross Engineering Div., Midland-Ross Corp.

Air Processing Equipment

This new 12-page bulletin includes data on ovens, driers, air heaters, and curing systems for use in such industries as pulp and paper, paint finishing, rubber and foam rubber, foundries, plastics, and chemical processing. The bulletin also includes six specific case histories covering drying or curing problems solved by properly designed equipment. Ask for Bulletin No. S-5. from J. O. Ross Engineering Division of Midland-Ross Corp., 730 Third Ave., New York 17, N. Y.

New Detroit Offices

Ground was broken recently for the new Detroit offices of J. O. Ross.

The new building, located at 13050 Puritan Ave. and scheduled for an early February completion, will house Ross engineering and office personnel plus representatives of the Midland-Ross Corp.

Milton Roy Co.

Determination

The Magnox Analyzer, a unit for the continuous determination of O_2 in gases, has automatic temperature compensation, yet uses no chemicals and has no moving parts. With an accuracy of ± 1 to 2% of full-scale and a stability of $\pm 1\%$ of full-scale over more than a year, the Magnox Analyzer provides accurate data for efficient fuel burning, permits economical ceramic firing and closer control of kiln atmospheres, measured the purity of oxygen and of nitrogen, and aids in control of fruit ripening and the treatment of raw tobacco. Request Bulletin 1059 from Milton-Roy Co., Philadelphia, Pa

Sulfuric Acid Pump Filter

Bulletin 459 describes specially designed sludge trap and filter which effectively traps and removes concentrated sulfuric acid sludge, allowing highly accurate controlled volume pumps to work at peak efficiency. Design features, operation, and diagrams are carefully explained.

Solvay Process Division, Allied Chemical Corp.

Appointments

Six appointments in the sales department of Solvay Process Division, Allied Chemical Corp., effective Jan. 1, 1960, were announced by Arthur Phillips, Jr., Solvay vice-president. Fred P. Boehm and Charles E. Varn were appointed assistant directors of sales.

Robert E. Clagett succeeds Mr. Boehm as Pittsburgh Sales Branch manager and G. Richard Barclay replaces Mr. Varn as manager of the New Orleans Sales Branch.

In addition, Jerome L. Hochenedel is appointed manager of Solvay's Houston, Texas Sales Branch, succeeding S. O. Taylor, who is retiring after 33 years of service with the company.

Richard A. Marshall has been named manager of the organic chemicals section, a post formerly held by Mr. Barclay.

Messrs. Boehm, Varn, and Marshall will make their headquarters at Solvay's New York City office, 61 Broadway.

Testing Machines, Inc.

Beach Puncture Tester

Literature illustrating and describing the TMI Beach Puncture Tester is now available from Testing Machines, Inc. This simple and reliable instrument is used for determining the resistance to puncture of currugated, corrugated board, fiber board, wall board, vulcanized fiber, plywood, and heavy liner.

Write to Testing Machines, Inc., 72 Jericho Turnpike, Mineola, N. Y.

Stiffness Testers

Testing Machines, Inc., TMI has now made available a data sheet illustrating and describing three different types of stiffness testers. The testers are used to evaluate the stiffness and resilient qualities of plasics, leather, paper, cardboard, light metallic sheet, foil, wire, and other flexible materials. For complete literature write to Testing Machines, Inc., 72 Jericho Turnpike, Mineola, N. Y.

Synkoloid Co., Inc.

Gelvatex Coatings Purchased

Gelvatex Coatings of Anaheim, Calif., has been purchased by the Synkoloid Co., Inc., of Los Angeles.

Gelvatex, a major West Coast manufacturer of polyvinyl acetate paints since 1950, was a division of Shawinigan Resins Corp. of Springfield, Mass.

In a joint announcement, R. K. Weck, president of Synkoloid, and W. R. Elliot, vice-president of Shawinigan, stated that Synkoloid has acquired the entire plant of the Gelvatex organization including all production equipment and research facilities.

The Synkoloid Co., a major producer of water base emulsion paints and water base specialty items, will manufacture a complete line of water base paints including all Gelvatex products at the Anaheim factory.

Sprout, Waldron & Co., Inc.

Watertight Sawtooth Crusher

The development of a watertight, saw tooth crusher for handling a wide assortment of chemical slurries has been announced by Sprout, Waldron. Designed so that all material in contact with the slurry is of stainless steel, the crusher is built to withstand a 20 ft. liquid head pressure.

The eighty-five $^{7}/_{32}$-in. saws are specified in type 403 stainless. All other areas in contact with the material being processed are fabricated from clad type 304.

The Thew Shovel Co.

65-Ton Lorain Moto-Crane

A four-page bulletin is now available on new 65-ton Lorain Moto-Crane model MC-760. Machine features hydraulically operated "Power-Set" Outriggers as standard equipment, sturdy nonweave chassis frame, 8 × 4 carrier, planetary rear bogie axles, turnpike speeds up to 37.6 m.p.h., removable counterweight, folding gantry, and precision control with spur gear driven boom hoist. Also contains Thew-Lorain's patented "Shear Ball" connection with 10 year warranty.

Specify bulletin No. 85743-9A for detailed information.

Edwin L. Wiegand Co.

Cast-Iron Electric Heaters

Edwin L. Wiegand Co., 7500 Thomas Blvd., Pittsburgh 8, Pa., offers a new Bulletin, PD106, illustrating its line of Chromalox Cast-Iron Electric Immersion Heaters.

These heaters are designed to give fast, accurate heating for melting soft metals at temperatures up to 950°C.

Remote Temperature Controller

The new type PC Chromatrol Electronic Controller gives highly sensitive temperature control, within 1°F., up to 600°F. The stainless steel sensing element is a very small bullet-probe only 1-in. long and $^{1}/_{4}$ in. in diameter. The pre-aged thermistor probe may be located in platens, in air ducts, and in immersion wells up to 100 ft. away from the amplifier-relay cabinet using inexpensive, light-gage, twisted lead wire.

Loads up to 10 kw. can be controlled directly without a separate magnetic contactor, and it may be used on 120, 208, or 240 v, 60 cycles. The scale covers dual-range from 25 to 225°F. or 200 to 600°F. The dial-plate control is removable from the amplifier-relay for remote location up to 30 ft. away. Thus all controls may be mounted at a single location.

For additional information and prices write the manufacturer, Edwin L. Wiegand Co., 7500 Thomas Blvd., Pittsburgh 8, Pa.

Westinghouse Electric Corp.

Motor-Load Indicator

A new motor-load indicator (C-371) for use on either single- or three-phase, 50- or 60-cycle induction motors is now available from Westinghouse. The device is designed for use with a 5-amp. current transformer.

The panel instrument measures the useful or working component of load current (I cos. θ). Since induction motors operate at different power factors, depending upon load, this device gives more accurate indication at light loads, without sacrificing full-load indication.

Motor-load indicator

For further information, write Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30, Pa.

T. B. Wood's Sons Co.

Variable-Speed Sheave

Wood's Bulletin No. 6102 describes new stationary control "SVS" variable-speed sheave for standard V-belts. The patented, positive-locking "SVS" sheave is available with two, three, or four grooves. The bulletin covers its nonfreezing construction, method of installation, easy speed change and other features.

T. B. Wood's Sons Co., Chambersburg, Pa.

General

13th Bolton Award Contest

"Through the Grapevine" is the subject of the 1960 Bolton Award Essay Contest according to a joint announcement by the Paper Industry Management Association, Chicago, Ill., and John W. Bolton & Sons, Inc., Lawrence, Mass., co-sponsors of the contest.

This is the 13th annual essay contest on subjects of importance to the pulp and paper industry and is open to all employees of pulp and paper mills in North America. The contest period extends from Jan. 1, 1960 until midnight, Mar. 31, 1960.

The sponsors of the contest stress that ideas, not writing skill, are of paramount importance in determining the winning essays. Papers may be as general or specific as entrants wish in their comments on "Grapevine" advantages or disadvantages, benefits or detriments.

Ten national cash prizes will be awarded—First prize, $1000; second prize, $750; third prize, $500; and seven prizes of $200 each.

Entrants are asked to submit their papers typed with double spacing on one side only on plain sheets, $8^1/_2 \times 11$ in. Papers should be confined to 1500 words. Cover sheets *only* are to include the author's name, home address, job title, and name and address of the mill.

All entries must be postmarked before midnight, Mar. 31, 1960, and mailed to the Secretary and Treasurer, Paper Industry Management Association, 10 N. Clark St., Chicago 2, Ill.

Contest winners will be announced at the 41st National Convention of the Paper Industry Management Association to be held in San Francisco in June. The ten prize-winning papers will be published in book form and distributed gratuitously throughout the industry.

U. S. Forest Products

Eight new or revised reports describing research work recently conducted on wood and related products, are available from the U. S. Forest Products Laboratory, Madison, Wis.

Information on the durability of sandwich construction panels with resin-treated paper honeycomb core after natural and accelerated exposure to the various weathering conditions is presented in Report No. 2158, "Durability of Resin-Treated Paper Honeycomb Core."

"Yield and Value of Finished Lumber from Western White Pine Trees and Logs," Report No. 2163, contains data on the effect that inherent characteristics of the logs, trees, timber stand, and logging practices had on the yield and quality of finished lumber obtained from timber harvested in northern Idaho.

"Some Physical and Mechanical Properties of Noble Fir," Report No. 2168 describes the more important characteristics of noble fir and provides data that can be reliably used for comparison with other species.

The results of research involving the use of certain western hardwoods for pulp in the production of corrugating board are presented in Report No. 2162, "Continuous Cold Soda Pulping of West Coast Red Alder, Tanoak, Madrone, and Bigleaf Maple."

The several steps required for finishing new and old floors, along with helpful tips on their care, are contained in a new report entitled, "Finishing and Maintaining Wood Floors," Report No. 2169.

Another report in the series of Veneer Cutting and Drying Properties is "Tanoak, " Report No. 1766-15, which describes some of the characteristics of tanoak affecting its use for the production of veneer and plywood.

"Engineering Calculations for the Distillation of the Furfural-Water System," Report No. 2070, presents data that extend pressures for the furfural-water system to about 20 atmospheres, and include an analysis of the distillation system of furfural water from an economic and engineering viewpoint.

Recent information on wood preservatives, methods of treating posts, and service-life expectancy of treated and untreated posts has been incorporated into the revised progress report, entitled "Service Records or Treated and Untreated Fence Posts," Report No. 2005.

Single copies of these reports are available free upon request from the Director, Forest Products Laboratory, Madison 5, Wis.

Pulp and Paper Industry Leasing More Equipment

Long-term leasing of production equipment by paper and pulp firms during 1959 spurted ahead, reaching a total of $12.6 million worth of equipment on lease, a gain of 52% over 1958.

This was disclosed by Robert Sheridan, president of Nationwide Leasing Co., Chicago. He predicted that equipment leasing in the paper industry would double in 1960 because

of three factors: (1) more equipment manufacturers are using leasing as a sales tool to move their products; (2) more companies will lease their equipment to avoid the pinch of tight money; and (3) more companies will be affected by the increasing technological progress which is speeding up obsolescence of machinery.

A complete analysis of equipment leasing has been developed by the Foundation for Management Research, entitled: "The Pros and Cons of Leasing." Single free copies may be obtained by writing to the Foundation at 121 W. Adams St., Chicago 3, Ill.

Total dollar volume of equipment on lease to all industries reached $307 million in 1959, a net gain of about $80 million. This compares to a 1958 gain of $47 million. This does not include cars, trucks, buildings, or railroad rolling stock.

OBITUARIES

Hendrik Willem Meijer

Hendrik Willem Meijer, managing director of O. J. Meijer's Dextrinefabrieken N. Y., Veendam, Holland, passed away last year.

After graduating from the university he joined O. J. Meijer, with which company he was associated until his death. Mr. Meijer was a member of TAPPI since 1949.

Gordon I. Hoover

Gordon I. Hoover, manager and technical director, Provincial Paper Ltd., Thorold, Ont., passed away Dec. 8, 1959.

Mr. Hoover was born in Toronto in September, 1900. After obtaining his master's degree from the University of Toronto, he went to Cambridge, England, for his doctorate. Returning to Canada he joined the Department of Cellulose Chemistry at McGill University where he stayed 2 years. In 1929, Mr. Hoover went with the Howard Smith Paper Co. in Montreal and in 1930, transferred to Provincial Paper Ltd.

Mr. Hoover, a member of the Technical Association since 1933, was very active in his support of the TAPPI Coating Committee for many years.

Asbjorn Borgesen

Asbjorn Borgesen, technical manager, Mathiesen-Eidsvold Vaerk, Bon, Norway, died in December, 1959. Born in Oslo, Norway, Feb. 10, 1899, Mr. Borgesen obtained his master's degree in 1923 from Norges Tekn. Hoyskole. From 1927 to 1930 he was in the United States. Returning to Norway he worked in various capacities at the Norges Tekn. Hoyskole, Aukers Papirfabrik, Saugbrugsforeningen, Vittingfoss Paperfabr. and Mathiesen-Eidsvold Vaerk. Mr. Borgesen became a member of TAPPI in 1954.

Julian Wells Maxson

Julian Wells Maxson, one of the founders of the Maxson Automatic Machinery Co., died Dec. 13, 1959, at The Westerly Hospital at the age of 78 years.

Mr. Maxson was born in Westerly on April 19, 1881. He graduated from Westerly High School, prepared at Phillips Exeter Academy, and spent two years at Harvard University as a special student.

In 1912 his father and he formed the Maxson Automatic Machinery Co. in Westerly, and operated the business as a partnership until 1932, when it was incorporated with his father as president and Mr. Maxson as vice-president. Upon his father's death in 1939, he assumed the presidency and held this office until his death.

He was widely known in the paper industry, for which the Maxson Automatic Machinery Co. manufactures handling and finishing machinery for the paper, board and pulp mills.

Mr. Maxson was a member of the Technical Association of the Pulp and Paper Industry since 1924.

Myrl Nelson Davis

M. N. Davis, 57, manager, Research Laboratories, Kimberly-Clark Corp., died unexpectedly Dec. 22, 1959, as he was en route to work.

Dr. Davis, a former chairman of the Gravure Technical Association, and who was chairman of the mechanical engineering group and an advisor to the optical properties section of the Technical Association of the Pulp and Paper Industry, had been associated with Kimberly-Clark since 1929. He was reputed to be the first full-time physicist employed in the paper industry.

A graduate of Milton college and the University of Wisconsin from which he received his doctorate, Dr. Davis was a member of the American Physical Society, the Optical Society of America, the American Institute of Physics, TAPPI since 1934, Gamma Alpha, and Sigma Xi.

Survivors include his widow, one daughter and three sons.

Hugh J. Chisholm

Hugh Joseph Chisholm, seventy-three, chairman of the board of the Oxford Paper Co., died of a heart ailment in his office at 230 Park Ave., Dec. 23, 1959. He lived at Strathglass, in Port Chester, N. Y.

Mr. Chisholm's company is one of the nation's largest book paper producers. It was organized by his father, the late Hugh J. Chisholm, in 1898.

Mr. Chisholm was born at Portland, Me. He was graduated from Yale in 1908 and received a law degree from Harvard in 1911. Then he went into Oxford company as secretary to his father. He became president on the death of his father in 1912.

He was also president of the Nashwaak Pulp and Paper Co., and a director of the Maine Central Railroad Co. and the Grace National Bank of New York.

Surviving Mr. Chisholm are his wife, Mrs. Sara Hardenbergh Chisholm; two sons, Hugh J., Jr., and William H. Chisholm, and a daughter, Mrs. Harold M. Cole.

Martin Luther Haggerty

Martin Luther Haggerty, executive vice-president of George La Monte & Son, Nutley, N. J., manufacturers of safety paper for checks, died January 10. He was 76 years old.

Mr. Haggerty, who joined the La Monte concern in 1904, became sales manager in 1910, a director in 1914 and vice-president in 1928. In 1954, he was elected executive vice-president. He was also an officer and director of the company's Canadian subsidiary.

During Mr. Haggerty's 56 years with the company, he was responsible for the major merchandising programs that expanded the use of safety paper for bank checks and other negotiable documents requiring protection against fraudulent alteration and counterfeiting.

TAPPI DIVISIONS AND COMMITTEES

Reports of Activities

Engineering Division Staff

The first Engineering Division Staff meeting at the 14th Engineering Conference was held starting at 8:00 p.m. in the Terrace Room of the Penn Sheraton Hotel in Pittsburgh, Oct. 11–14, 1959. The following individuals were in attendance:

Division Officers: J. R. Curtis, *chairman;* J. M. Osborne *vice-chairman;* V. P. Owens, *secretary;* H. O. Teeple, TAPPI Staff, Jack Winchester, TAPPI Staff
Advisory Committee: J. D. Lyall
Chemical Engineering Committee: A. W. Plummer
Civil Engineering Committee: W. Pittam; C. E. Bouis
Corrosion Committee: E. W. Hopper; H. W. Fritts
Drying Committee: S. G. Holt
Electrical Committee: R. F. Sorenson; I. Witham; G. E. Shaad
Engineering Data Committee: H. O. Teeple
Engineering Economics Committee: Not represented
Fluid Mechanics Committee: N. S. Shoumatoff, J. A. Smith
Industrial Engineering Committee: B. C. Kendall
Maintenance Engineering Committee: R. Q. Connor
Mechanical Engineering Committee: M. N. Davis
Process Instrumentation Committee: J. K. Powell, B. W. Prince, R. D. Clarke
Sanitary Engineering Committee: W. A. Moggio, L. L. Klinger
Steam & Power Committee: R. V. Knapp, H. R. Emery, W. B. Wilson

The discussions of this meeting followed the agenda which have been established by J. R. Curtis, Division chairman and distributed to the chairmen, vice-chairmen, and secretaries of the various committees. The points discussed pertain to the items listed on the agenda and they are described in the following paragraphs following the form of the agenda.

1. Report of local Committee Chairman. Marty Fisher, local arrangements chairman, gave a report on the final arrangements made with the hotel for the various sessions. This was followed by a review of the needs of the various committees for equipment for their sessions.

2. Introduction of New Committee officers by Committee Chairman. J. R. Curtis, retiring chairman of the Engineering Division, announced that he would be succeeded by J. M. Osborne as chairman. Mr. Osborne would be succeeded by N. Shoumatoff as vice-chairman of the Engineering Division.

Corrosion Committee—H. B. Harris, Jr., Union Bag-Camp Paper Co. Savannah, Ga., is the new Vice-chairman. A. O. Caldwell Service & Erection Co., Pittsburgh, Pa., is the new secretary.

Electrical Committee—S. Andersen, West Virginia Pulp & Paper Co., New York, N. Y., is now chairman. E. G. Parrish, Crossett Paper Mills, Crossett, Ark., is now vice-chairman. H. A. Wright, Allis-Chalmers Co., West Allis, Wis., is now secretary.

Fluid Mechanics Committee—C. A. Lee, Formex Co., Knoxville, Tenn., is the new chairman. G. L. Calehuff, West Virginia Pulp & Paper Co., Covington, Va., is the new vice-chairman.

Maintenance Engineering Committee—M.H. Reed Jr., International Paper Co., Springhill, La., is the new chairman. W. R. Palmer, Link-Belt Co., Shreveport, La., is the new secretary.

3. Report on Pending Changes in Committee Staffs by Committee Chairmen. Discussions were held which pointed out that chairmen and vice-chairmen should be mill personnel. They are recommended by committee officers and approved by the Engineering Division Chairman and President of TAPPI. The secretaries are usually mill supply personnel and are picked by the committee with no higher approval necessary.

Various committees discussed the organization of their over-all committee, breaking it down into Steering Committee and various subcommittees to handle individual projects.

4. Committee Membership.

a. Corrosion Committee. E. W. Hopper reported that he extended invitations for committee membership by personal letters to selected individuals or managements of companies who should have interest in corrosion work in the pulp & paper industry. He reported good response and enthusiasm by personnel of the allied industries.

b. Fluid Mechanics Committee. N. Shoumatoff reported that the Fluid Mechanics Committee was the newest committee in TAPPI, but their drive for membership has resulted in a high percentage for mill personnel. He reported that he obtained an active group by talking with interested personnel at TAPPI meetings.

c. The division secretary reported that suggested names for committee members had been extracted from the new membership list published by TAPPI headquarters. These lists were sent to the various committee chairmen, but there was little indication of follow-up on this. It was agreed that this system would be continued and the committee chairmen were urged to write to the individuals who were listed. Some committees, of course, are able to obtain adequate members through direct approach to them by interested personnel.

d. General Approach for Soliciting Members for Specific Projects. E. W. Hopper reported that he had used this approach with good results.

e. No comments.

f. General Discussion. M. J. Osborne reminded everyone that each should try to keep TAPPI members and TAPPI member employers enthusiastic by reporting on results of committee projects.

5. Report on Interim Meetings from Functional Standpoint.

a. Electrical Committee reported that it had been holding interim meetings for the last 5 years and during the last three years, the meetings were being held with the A.I.E.E. The committee reported excellent results and that it could not function properly without such interim meetings. It was reported that in these interim meetings papers are reviewed, reports are followed on subcommittees, projects are discussed and forthcoming conference programs are considered. This committee also reported that its subcommittees are divided in functional areas of electrical operations in mills. The committee also reported that in a few cases it has geographical arrangements of subcommittees.

b. Steam & Power Committee reported that it has been having interim meetings for 6 years. With the exception of the last year's meeting, which was held in Chicago, all meetings had been held at the Pittsburgh Airport Hotel. All of the work of the committee as a group is accomplished at the interim meetings. It is now suggesting a 2-day meeting.

c. General Discussion. Fluid Mechanics, Process Instrumentation, and Chemical Engineering committees reported that they were having interim meetings of Steering Committees.

The question was asked "which committees had interim meetings in New York in February." Both Corrosion and Chemical reported that they held interim meetings at that time, but that they were not effective.

6. Report on Engineering Division Policy Manual. H. O. Teeple reported that Policy no. 7 should be reviewed by each committee and they should resubmit any corrections to their scope of individual committee, to the division secretary by Dec. 31, 1959.

7. Report on Instructions to Authors. Mr. Teeple reported that TAPPI Headquarters staff was in a position now to go to direct contact with the authors of papers. This is expected to eliminate the pile-up of work associated with the last minute hustle to obtain paper abstracts and manuscripts.

Mr. Lyall suggested that with the "Instructions to Authors," we include a copy of the Engineering Division Policy on complimentary registration. This item is to be further reviewed by the Engineering Division Officers and Staff Advisory Committee.

8. Review of TAPPI Research Policy. J. R. Curtis reported that the research work on TAPPI would be divided into two phases: (1) short range and (2) long range. He reported that the funds for research would come from corporate membership dues and not from individual membership dues. The present amount of money spent on research by TAPPI is between $600,000 and $700,000. The corporate dues amount to approximately $115,000.

9. Discussion of Division Project Advisory Committee. It was announced that such a committee would be formed and that the object of this committee would be to review all projects and committee activities.

10. Invoice Procedure for TAPPI Financed Projects. These invoices are to be signed by the subcommittee in charge of the project and sent to H. O. Teeple at TAPPI Headquarters.

11. Review of Interim Committee Report Forms to Be Returned at Wednesday Meeting. Mr. Curtis pointed out that this form included all the information needed for the annual TAPPI report by individual committees. He pointed out that the annual Engineering Division report would be composed of the individual committee reports.

12. Review of Session Analysis Forms & Procedures for Committee Chairmen as Session Moderators. These new forms were circulated and were to be returned at the Wednesday meeting.

13. Complimentary Registrations. Only about six requests have been made for complimentary registrations. Some have been arranged in accordance with the instructions previously submitted to each committee. The matter was still not being handled properly and further discussions would be necessary following the performance at the 14th Engineering Conference.

14. Seating at Wednesday Luncheon. Mr. Curtis pointed out that the retiring chairman of each committee was expected to sit at the head table at the Engineering Staff Division Luncheon on Wednesday. Committee vice-chairmen and secretaries were to be seated at round tables immediately in front of the speaker's table.

15. Future Conferences. (a) 1960—Jacksonville; (b) 1961—Washington, D. C.; and (c) 1962—Montreal.

16. Specific Comments and Problems by Committee Chairmen. No additional comments or discussions were held.

Wednesday Luncheon

The second main function was the Conference Luncheon which was held on Wednesday in the Ballroom of the Penn Sheraton Hotel. J. R. Curtis introduced the committee chairman, as well as the vice-chairman and secretaries. J. R. Lientz, president of TAPPI, sat at the speaker's table and presented Certificates of Appreciation to retiring chairmen. He also presented a Certificate of Merit and Appreciation to Dan Patch of the Industrial Engineering & Materials Handling Committee.

Mr. Curtis gave an outstanding talk on the subject, "A Challenge of Industry to Engineers." This very interesting article was published in the October issue of *Tappi*.

Mr. Curtis introduced M. J. Osborne as the new chairman of the Engineering Division and N. Shoumatoff as the new vice-chairman.

Engineering Division Staff Dinner

The final meeting of the Engineering Division Staff was a dinner meeting which was held in the Penn Sheraton Hotel on Wednesday evening, Oct. 14, 1959.

This meeting was attended by the following:

Staff: J. R. Curtis, *retiring chairman;* M. J. Osborne, *chairman;* N. S. Shoumatoff, *vice-chairman;* V. P. Owens, *secretary*
Local Arrangements Committee: M. H. Fisher, R. Digby, W. G. Gerstacker, A. O. Caldwell, W. R. McNally
Staff Advisory Committee: J. D. Lyall
Chemical Engineering Committee: A. W. Plummer
Civil Engineering Committee: C. E. Bouis
Corrosion Committee: E. W. Hopper, H. W. Fritts
Data Sheets Committee: H. G. Ingraham
Drying Committee: K. K. Khandelwal
Electrical Engineering Committee: H. A. Wright, R. F. Sorenson, G. E. Chaad, I. Witham
Engineering Economics: F. C. Holmes
Fluid Mechanics: C. A. Lee, G. L. Calehuff
Industrial Engineering & Materials Handling: B. C. Kendall
Maintenance Engineering Committee: R. Q. Conner
Mechanical Engineering Committee: J. C. Harper
Process Instrumentation: J. K. Powell, E. W. Prince, Bob Clarke
Sanitary Engineering Committee: W. A. Moggio
Steam & Power Committee: H. R. Emery, W. B. Wilson
Tappi Headquarters: H. O. Teeple, A. J. Winchester

The agenda and comments pertaining to this were in accordance with the agenda as set up by Ray Curtis:

1. Informal get-together—no comments.
2. Dinner—no comments.
3. Report of Local Committee. M. H. Fisher, chairman of the Local Arrangements Committee, reported that the Local Arrangements Committee felt that the conference had proceeded in an excellent manner and was satisfied with the over-all results. He reported that there were approximately 796 registrants of which 103 were ladies; 473 people attended the luncheon held Wednesday and 574 people attended the evening banquet on Tuesday.

Ed Hopper reported that the income from the conference up to the present time was roughly, $16,000 and he felt that a favorable financial balance would result.

W. R. McNally reported on the registration. He said that the advance registration for the Pittsburgh conference proved expensive since only 130 men and 28 women used the preregistration facilities. Bill was willing to recommend that they try preregistration again in Jacksonville next year, but advised that it should be handled from New York.

4. Reports from Committee Chairmen.

a. Chemical Engineering. A. W. Plummer reported no major problems. Sixteen men attended the committee luncheon. They ran into a minor problem at their scheduled breakfast meeting because their room was not ready. They had to solve the problem by retiring to a large table in the coffee shop. He reported an overflow from the room used for their operations research program which had a maximum of about 125 people. He also reported that they had a difficult time with the projectors at their afternoon session. The turnout at the afternoon session was very small.

14th Engineering Conference, Engineering Data Committee meeting, H. G. Ingraham, Chas. T. Main, Inc., chairman

b. Civil Engineering. C. E. Bouis, committee secretary, reported that they had a large turnout at their first session. He reported that W. Pittam had to leave and regreted that he was not able to attend the staff dinner.

c. Corrosion Committee. E. W. Hopper reported that the luncheon was attended by 29 committee members and guests. A. O. Caldwell is the new committee secretary. They will develop a subcommittee for "Alkaline Digester Corrosion and Over-Lays." They presented four papers at their morning meeting which was attended by approximately 100 people. In their afternoon session, they had an overflow turnout of 150 people and an enthusiastic discussion which lasted until 6 p.m.

d. Drying Committee. S. G. Holt reported that 17 members out of a total of 23 were present at the meeting. Two new members have been added. Four papers were presented. He reported that a problem developed in scrambling for preprints.

e. Electrical Committee. R. F. Sorenson reported that the committee found the solid 3-hr. session to be most desirable. They had too many papers scheduled for their session. The only major problem that they had during the session was painters walking in and out of the conference room. They had 25 committee members and three guests present at their committee luncheon. They also had a meeting of their steering committee and three subcommittee meetings during the conference.

f. Engineering Economics Committee. F. C. Holmes reported only seven men showed up for the committee luncheon, and a problem developed with the payment of the luncheon based upon the minimum attendance guarantee. The Economics session has an enthusiastic turnout of 125 people. The only complaint about the arrangements was that the requested "VU Graph" did not arrive until five minutes before the program started. They were, of course, apprehensive because presentation of the papers depended upon the use of the projector.

g. Fluid Mechanics. N. Shoumatoff reported 28 people at their luncheon and an excellent progress made a their committee luncheon. They, too, had projector trouble. He reported 200 people attending the sessions for the presentation of papers.

h. Industrial Engineering. B. C. Kendall announced that he had only 50 people at the start of the session, but that the group increased to 125 people at the end. He had two outstanding speakers and felt embarrassed for the small turnout at the beginning. He also reported projector trouble. He recommended that all future slides be put on glass and be of the 35 mm. size.

i. Maintenance Engineering. R. Q. Connor reported that 150 people attended their session during the presentation of papers. He reported that 22 people attended their committee luncheon. The attendance list consisted of 11 members, one Engineering Division Staff, six guests, and four prospective committee members. He also announced that Harold Reed was their new committee chairman.

j. Mechanical Engineering. J. C. Harper reported an attendance at their meeting running about 125 to 175. They had 22 present at their committee luncheon and 16 out of 22 committee members were present. They also had major problem with projectors.

k. Process Instrumentation. J. K. Powell reported that they had a steering committee meeting on Sunday evening, attended by four committee members. They had 16 members at their committee meeting at 6 p.m. on Sunday. They had projector trouble caused by the poor condition of the projector.

1. Sanitary Engineering. W. A. Moggio reported that they had 70 present at their paper presentation. Their papers were excellent. They experienced no trouble.

m. Steam & Power. H. R. Emery reported that they has 13 present at their get-together breakfast, for their speaker and round-table discussion participants. They experienced some trouble because the assigned room was not ready for the breakfast but W. B. Wilson, with the help of the Hotel Conference Office, was able to make suitable arrangements before the scheduled time. The very short delay caused no complications. They reported 140 people present at the start of this session and 190 people at the session on papers. They had 155 people present at the Panel Discussion. Twenty-two out of 26 committee members attended the conference. They had a special committee meeting on Wednesday afternoon on "Recovery Unit Operation."

5. General Discussion. The following committees gave reports for their future planning.

a. Chemical Engineering. It was two interim meetings planned. The committee is continuing their Project No. 780 on chemical engineering problems as well as continuing its work on the survey of chemical engineers in the industry.

b. Civil Engineering. Mr. Bouis reported that the members plan to have an interim luncheon meeting in New York in February. They plan to present one paper at the February 1960, meeting. They need two or more papers for their 1960 conference program in Jacksonville. They are reviewing their data sheets.

c. Corrosion Committee. E. W. Hopper reported that they had enough papers for the 1960 meetings, both in February and October.

14th Engineering Conference, Steam & Power Committee meeting, R. V. Knapp, Mossinee Paper Co., chairman

Committee	Chairman	Vice-Chairman	Secretaries
Chemical Engineering	A. W. Plummer Hudson Pulp & Paper Corp. South Windham, Me.	J. Lewis	R. F. Clemens Dorr-Oliver Corp. Stamford, Conn.
Civil Engineering	William Pittam Stone & Webster Engr.	Stone & Webster Toledo, Ore.	C. E. Bouis Southwestern Engr. Los Angeles, Calif.
Corrosion	E. W. Hopper Pittsburgh, Pa.	H. B. Harris, Jr. Union Bag-Camp Paper Co. Savannah, Ga.	Alan O. Caldwell Service & Erection Co. Pittsburgh, Pa.
Drying	S. G. Holt Consolidated Water Power & Paper Co. Wisconsin Rapids, Wis.	G. E. Jackson Bowaters Carolina Corp. Catawba, S. C.	K. K. Khandelwal Dewey & Almy Chemical Co. Cambridge, Mass.
Engineering Data	H. G. Ingraham Charles T. Main, Inc. Boston, Mass.		H. O. Teeple TAPPI New York, N. Y.
Electrical	S. Andersen West Virginia Pulp & Paper New York, N. Y.	E. G. Parrish Crossett Paper Mills Crossett, Ark.	H. A. Wright Allis-Chalmers Co. West Allis, Wis.
Engineering Economics	G. W. Sargent, Jr. Mercury Engineering Milwaukee, Wis.		F. C. Holmes Bird Machine Co. Evanston, Ill.
Fluid Mechanics	C. A. Lee Formex Co. Div. of F. C. Huyck & Sons Knoxville, Tenn.	G. L. Calehuff West Va. Pulp & Paper Co. Covington, Va.	J. A. Smith Clark & Vicario Corp. N. Tarrytown, N. Y.
Industrial Engineering & Materials Handling	B. C. Kendall San Francisco, Calif.	D. D. Hall Eastern Fine Paper & Pulp Div. Standard Packaging Corp. Bangor, Me.	H. A. Stoess, Jr. Fuller Co. Catasauqua, Pa.
Maintenance Engineering	H. M. Reed, Jr. International Paper Co. Springhill, La.		W. R. Palmer Link Belt Co. Shreveport, La.
Mechanical Engineering	M. N. Davis [Deceased] Kimberly-Clark Corp. Neenah, Wis.	J. S. Mudgett Strathmore Paper Co. W. Springfield, Mass.	J. C. Harper Rice-Barton Corp. Worcester, Mass.
Process Instrumentation	J. K. Powell Bowaters Southern Paper Co. Calhoun, Tenn.	E. W. Prince Champion Paper & Fibre Co. Hamilton, Ohio	R. D. Clarke Minneapolis-Honeywell Regulator Co. Philadelphia, Pa.
Sanitary Engineering	William A. Moggio Lake States Yeast & Chem. Div. St. Regis Paper Co. Rhinelander, Wis.		L. L. Klinger Whippany Paper Bd. Co. Whippany, N. J.
Steam & Power	H. R. Emery St. Regis Paper Co. Jacksonville, Fla.	C. W. Wills Halifax Paper Co. Roanoke Rapids, N. C.	W. B. Wilson General Electric Co. Schenectady, N. Y.

d. Drying Committee. Mr. Khandelwal reported that the committee has interim meeting planned in December. It needs two more papers for the 1960 conference. One paper planned by H. A. Smith is available.

e. Electrical Committee. Mr. Andersen reported that his committee has three papers and a panel discussion planned for the Jacksonville meeting. It will hold an interim meeting in April in Gainsville, Fla.

f. Engineering Economics. Mr. Holmes reported no program established as yet for the 1960 meeting.

g. Fluid Mechanics. Mr. Lee reported that his committee planned to present three papers at the February, 1960, Annual Meeting and will also hold a committee meeting in February. It will hold two interim sessions, one in Michigan in December, and one at M.I.T. in January. The research project at M.I.T. will result either in a TAPPI paper of a manuscript.

h. Industrial Engineering. Mr. Kendall reported that for the 1960 schedule his committee is planning a panel discussion on "Finishing Room," and a paper on "Clay Storage and Handling." An interim meeting will be held in December or January. The Committee has 26 data sheets in process.

i. Maintenance Engineering. No future planning set up as yet. W. R. Palmer of Link-Belt in Shreveport, La., will be the new committee secretary.

j. Mechanical Engineering. Mr. Harper reported the steering committee will have a meeting in November and that the committee will have an interim meeting in New York in December or January. He reported that the committee is in need of mill personnel.

k. Process Instrumentation. Mr. Powell reported that his committee has two active projects scheduled for completion in January, 1960. For the 1960 Engineering Conference, four papers are scheduled. An interim meeting is planned in Pittsburgh on April 7.

l. Sanitary Engineering. Mr. Moggio reported that no interim meeting is scheduled and that there are prospects for three good papers for the 1960 engineering conference.

Committee Officers

Engineering Division

Chairman: M. J. Osborne, Bowaters Southern Paper Co., Calhoun, Tenn.
Vice-Chairman: N. S. Shoumatoff, West Virginia Pulp & Paper Co., New York, N. Y.
Secretary: V. P. Owens, Combustion Engineering, Inc., New York, N. Y.

Staff Advisory Committee

W. C. Bloomquist, General Electric Co., Philadelphia, Pa.
J. R. Curtis, Scott Paper Co., Chester, Pa.
J. W. Hemphill, Singmaster & Breyer, Inc., New York, N. Y.
J. D. Lyall, Armstrong Cork Co., Lancaster, Pa.
E. H. Olmstead, The Eaton-Dikeman Co., Mt. Holly Springs, Pa.
V. P. Owens, Combustion Engineering, Inc., New York, N. Y.
M. J. Osborne, Bowaters Southern Paper Corp., Calhoun, Tenn.
N. S. Shoumatoff, West Virginia Pulp & Paper Co., New York, N. Y.
H. O. Teeple, New York, N. Y.

m. Steam & Power Committee. Mr. Emery reported that the committee program for 1960 is complete. There will be an interim meeting in Chicago in the spring.

Fluid Mechanics Committee

The Fluid Mechanics Committee, Engineering Division, met in Room 566 of the Hotel Penn Sheraton, Pittsburgh, Pa., on Oct. 13, 1959, at 12:30 p.m. for a luncheon meeting with Nicholas Shoumatoff, retiring chairman, presiding.

The following members were present:

G. L. Calehuff, West Virginia Pulp & Paper Co.
F. R. Forrest, Allis-Chalmers Co.
W. E. Guthrie, Eastman Kodak Co.
C. A. Lee, Formex Division, F. C. Huyck & Sons
J. D. Lyall, Armstrong Cork Co.
K. J. Mackenzie, Eastman Kodak Co.
L. A. Moore, Black-Clawson Co.
N. Shoumatoff, West Virginia Pulp & Paper Co.
J. A. Smith, Clark & Vicario Corp.
P. E. Wrist, The Mead Corp.

Present also were the following subcommittee members, authors, and guests of the Committee:

G. Bugliarello, Carnegie Institute of Technology
L. A. Burnham, Procter & Gamble Co.
J. W. Daily, Massachusetts Institute of Technology
Walter Debler, University of Michigan
K. Fischer, Fischer & Porter Co.
F. C. Haas, Rensselaer Polytechnic Institute
E. J. Justus, Beloit Iron Works
L. H. Mahony, Mixing Equipment Co., Inc.
H. Nelson, Kimberly-Clark Corp.
J. Y. Oldshue, Mixing Equipment Co., Inc.
N. Reitzel, West Virginia Pulp & Paper Co.
E. D. Schwandt, Goulds Pump Co.
G. V. Shaw, Ingersoll-Rand Co.
J. P. Smoots, Jr., E. I. du Pont de Nemours & Co.
A. C. Spengos, Scott Paper Co.
R. Swenson, St. Regis Paper Co.
V. E. Ware, Warren Pump Co.

The chairman opened the meeting by introducing the various members, guests, and authors of technical papers present.

At the suggestion of the chairman the Minutes of the previous meeting at the Hotel Commodore, New York, on Feb. 24, 1959, were accepted unanimously and without reading. Similarly, the minutes of the previous meetings of the subcommittees on Free Surface Flow at the University of Michigan and on Dilute Fiber Suspensions at the Massachusetts Institute of Technology were accepted unanimously without reading.

Mr. Shoumatoff announced the appointment of Mr. Lee as the new chairman of the fluid Mechanics Committee commencing with the termination of this meeting. He also introduced G. L. Calehuff as the new vice-chairman succeeding Mr. Lee. Mr. Shoumatoff now becomes vice-chairman of the Engineering Division.

14th Engineering Conference, Pittsburgh, Pa., Fluid Mechanics Committee, N. Shoumatoff, West Virginia Pulp & Paper Co., chairman

Mr. Shoumatoff reported that work under TAPPI Research Project No. 146 had been terminated at the Massachusetts Institute of Technology with the results being reported in a paper to be presented by J. W. Daily at the afternoon Fluid Mechanics Session. Dr. Daily stated that this report has been published in the form of Technical Report No. 35 of the Hydrodynamics Laboratory of the Massachusetts Institute of Technology and could be obtained at a cost of $1.50 each prior to the publication of the complete paper by TAPPI The question of publication of all of the reports submitted by the M.I.T. group on the subject of Dilute Fiber suspensions was discussed. Mr. Lyall suggested a possible TAPPI monograph compiling all of the various reports. It was suggested that Mr. Daily investigate the format to fit the requirements of such a monograph. In a motion by Mr. Wrist the proposed monograph was approved by 15 members with three dissenting.

In the discussion of the pros and cons Mr. Mackenzie pointed out that the usual TAPPI monograph includes conclusions with facts presented whereas he felt that the work at the Massachusetts Institute of Technology was primarily a matter of reporting facts alone. In this sense then these reports would not fit in within the strict definition of a TAPPI monograph as heretofore utilized. Mr. Justus mentioned that it would be a great physical convenience to have all of the M.I.T. reports on this subject bound and filed in the form of a TAPPI monograph for ease of ready reference and use.

It was agreed that Mr. Shoumatoff would check with TAPPI headquarters and would report to Mr. Lee existing TAPPI regulations, defining subjects and contents of TAPPI monographs.

Mr. Shoumatoff distributed copies of the current proposal for TAPPI Research Project entitled, "Turbulent Transfer Mechanics with Neutral Buoyant Suspensions," dated July 27, 1959, in the amount of $17,750. It is hoped that this request for research funds will be approved by the research Appropriations Committee so that the work at the Massachusetts Institute of Technology can continue.

The discussion next turned to the work under current TAPPI Research Project No. 156 at the University of Michigan. As previously reported, C. S. Yih is now at Cambridge University in England and his supervision taken over by Walter Debler of the University of Michigan. Mr. Spengos, coauthor with Dr. Yih of previous papers on this subject, has now received his doctorate and has joined the Scott Paper Co. The existing project No. 156 will continue to Jan. 1, 1960, with a final report to be presented at the Engineering Division meeting at Jacksonville, Fla., in October, 1960. The future of this project will be considered further at the forthcoming meeting of the subcommittee on Free Surface Flows to be held before the expiration of this calendar year.

A third area discussed concerned the work of the Pipe Friction subcommittee headed by Mr. Mackenzie. He reported a meeting of the subcommittee on October 12 at which it appeared that an educational program should be undertaken with the various engineering departments of paper companies concerned with the selection of centrifugal pumps to acquaint them with the results using the shear tester developed by this subcommittee at the University of Maine for measuring stock friction characteristics. Mr. Mackenzie further reported that results from tests of friction loss through valves and fittings recently accomplished at the University of Maine would be prepared in the form of a TAPPI Data Sheet. The various centrifugal pump manu-

facturers have been cooperating actively with the subcommittee in the use of motion pictures illustrating the use of the shear tester.

Mr. Lee, in his capacity as retiring chairman of the Data Sheet Subcommittee, then discussed certain pump and flow factor data sheets which have been returned to the Pipe Friction Subcommittee with comments from the Engineering Division Data Sheet Committee.

Mr. Lyall suggested as possible Data Sheets for the Fluid Mechanics Committee in the future: (1) water removal in table rolls, (2) thermodynamics of vacuum pumps, (3) Taylor vortices.

Also on the subject of Data Sheets, Mr. Shoumatoff as new vice-chairman of the Engineering Division assumes the responsibility for the question-and-answer column in *Tappi* under the Engineering Division masthead. It was pointed out that this column could be a source of possible subjects for both Data Sheets and/or research projects for committee consideration.

The next subject discussed was that of possible technical papers for presentation at the Engineering Division meeting at Jacksonville, Fla., in October, 1960. Mr. Shoumatoff said that Dr. Debler had been advised that because of the short period of time between the conclusion of this work and the February meeting the final report on the project No. 156 might better be presented at the Jacksonville meeting.

As regards a report on the continuation of the project at the Massachusetts Institute of Technology, provided it is granted, Dr. Daily pointed out that his group had presented talks at the past four Engineering Division sessions and hence felt that it might be advisable to postpone this report until a later session, possibly in 1961.

Mr. Mackenzie suggested the desirability of papers by machinery builders in the general area of headbox design. Mr. Shoumatoff agreed that the subject of application of fluid mechanics fundamentals was of equal importance with the basic research covering those fundamentals. Mr. Justus said that a paper covering the general philosophy of headbox design rather than the individual details was the type which this committee might well consider. Mr. Moore stated that the fundamental question was not the desirability of this type of paper but rather the proper committee to which this work should be assigned, and in deriving the history of the Fluid Mechanics Committee, pointed out that it filled a fundamental need for investigating principles of fluid mechanics as applied to the pulp and paper process rather than the equipment itself which might be evolved from a consideration of these principles.

Mr. Shoumatoff then turned the meeting over to Mr. Lee, the incoming chairman. Mr. Lee announced the appointment of Mr. Wrist as the new chairman of the subcommittee on Free Surface Flows, and confirmed the appointment of existing chairman, Mr. Mackenzie, of the Stock Friction Subcommittee and S. G. Mason of the Subcommittee on Dilute Fibre Suspensions. Mr. Calehuff, in his capacity as vice-chairman of the Fluid Mechanics Committee, becomes the chairman of the Data Sheets Subcommittee. Interim meetings of the various subcommittees will be set up and the dates announced in the near future by the subcommittee chairman.

The meeting was adjourned at 1:45 p.m.

J. A. Smith, *Secretary*

Mechanical Engineering Steering Committee

The first meeting of the newly formed Steering Committee of the Mechanical Engineering Committee was held at TAPPI headquarters conference room at 10:00 a.m. Tuesday, Dec. 1, 1959. The following were present:

M. N. Davis, *chairman*
J. C. Harper, *secretary*
C. E. Hill
L. A. Moore
G. H. Spencer
H. O. Teeple

This meeting was called primarily to initiate plans for the program to be presented at the 15th Engineering Conference to be held at the Hotel Robert Meyer in Jacksonville, Fla., Oct. 24–28, 1960, and secondarily to discuss the organizational and operational problems of this committee.

Apropos to the forthcoming conference, H. O. Teeple provided the group with the latest information concerning meeting schedules, hotel facilities, and the like.

A new arrangement of the technical sessions is being planned for this conference as follows:

Monday—Technical sessions all day.
Tuesday—Technical sessions morning only. Mill visits in afternoon
Wednesday—Technical sessions all day. Banquet in the evening.
Thursday—Technical sessions all day. Staff dinner in the evening.

It will be noted that the customary Wednesday Luncheon is to be omitted.

The tentative program schedule indicates that the Mechanical Engineering Committee session will be No. 8 on Wednesday morning. The Committee Luncheon is scheduled for Monday at 12:30 p.m.

It was suggested that those planning to attend the conference should make their own hotel reservations well in advance as a large attendance is expected and accommodations are limited. Reservations should be made directly to the hotel as the local committee is *not* making hotel reservations for you as has been the practice at previous conferences.

Chairman Davis reported on letters that have been written to those who attended the 14th Engineering Conference and indicated an interest in the Mechanical Engineering Committee. Very few replies have been received to date, and it was decided to follow up the letters with additional correspondence and personal contacts. It is believed that some of these men might be interested in special work on one of the sub committees.

The subject of membership led to a discussion concerning the desirability of recruiting members from a large cross section of the paper industry, and still contain the group as a working-size committee. It was agreed that, subject to the discretion of the chairman, membership is to be limited to not more than two members from any single company.

Chairman Davis requested that serious consideration be given to the organization, staffing, and activities of the subcommittees. At present only the subcommittee on paper machines under C. E. Hill has a definite program of activities and is reasonably well staffed. The Wood Preparation Subcommittee has no chairman or members at present. The Stock Preparation Subcommittee under R. T. DePan has no staff and is not presently engaged in any projects. The same situation exists with the Finishing & Converting Subcommittee. As far as can be determined, the Data Sheets Subcommittee is functioning, but could use more members.

It was agreed that the subcommittee chairmen are to provide, or will be provided with, "willing and able" secretaries, to be "drafted" from the supplier group. Chairman Davis was requested to advise all subcommittee chairmen that they are expected to plan and produce suitable conference papers for future conferences, and that a full report on their intentions is to be submitted at the next general committee meeting.

Chairman Davis was also requested to start an immediate search for a suitable and active chairman for the Wood Preparation Subcommittee, and also recommend suitable secretaries for the subcommittees.

G. H. Spencer proposed, as a possible subcommittee project a subject which would appear to be a definite problem for the Mechanical Engineering Committee, with the following question: "Is there anyone in the paper industry capable of collecting the data to date-to try to solve the question of "barring?"

H. O. Teeple reported the latest thinking of the Engineering Division Staff Committee Advisory concerning printing and publication of technical papers.

After considerable discussion of subjects, projects, and available material, a tentative list of papers for presentation at the 15th Engineering Conference was arranged as follows:

1. "Uniform Nip Loading Control of Machine Calenders." Data from the Black-Clawson Co. with author to be selected later.
2. "Calender Nip Pressure Distribution as a Function of Local Roll Crowns and Temperature Variations," to be presented by someone from Kimberly-Clark Corp.
3. "Mechanical Design and Installation Requirements of Trailing Blade Coater Equipment," J. P. Munton, Rice Barton Corp.

This program is tentative and subject to the approval or alteration by the full committee at the next meeting.

It was decided to hold an interim meeting of the Mechanical Engineering Committee at 10:00 a.m. Tuesday, Jan. 12, 1960, in the conference room at TAPPI headquarters, 360 Lexington Ave., New York, N. Y.

All members are requested to attend this important meeting if possible. Please make a note of the date *now*.

The agenda of the meeting will consist of: (1) old business and comments on the actions of the Steering Committee; (2) reports from subcommittees; (3) discussion of the 15th Engineering Conference program; and (4) plans for future subcommittee projects.

Whether or not your are able to attend this meeting, you are requested to submit your comments and suggestions in writing, thus providing the officers and all members of the committee with a clear conception of the opinions and desires of the respective members. Along with these comments will you please indicate your choice of subcommittee assignments so that the chairman will be in a position to make assignments to your greatest personal interest.

The secretary was instructed to include in these minutes the following paragraphs from the "Application for Committee Membership" form which all of us have signed:

Paragraph 10. "Committee members are expected to: (a) attend scheduled committee meetings. (b) reply promptly to all committee correspondence. (c) perform committee assignments.

Paragraph 11. "It is expected that an applicant will have his company's approval for participation.

Pledge. "I have reviewed the above conditions of membership and do hereby make application for membership in the Mechanical Engineering Committee of the Engineering Division of TAPPI for the year 1960. I shall make a sincere effort to abide by the stated conditions of membership, and shall further the general objectives of TAPPI to the best of my ability."

J. C. Harper, *Secretary*

Process Instrumentation Committee

The Process Instrumentation Committee met Oct. 12, 1959, at 14th Engineering Conference which was held at the Penn Sheraton Hotel, Pittsburgh, Pa.

Committee Officers: J. K Powell, *chairman;* E. W. Prince, *vice-chairman;* R. D. Clarke, *secretary*

Committee Membership

Attending:

R. D. Clarke
C. S. Connor
H. D. Couture, Jr.
C. W. Dawson
H. P. Fishwick
L. G. Good
G. L. Harman
J. R. Lavigne
C. E. McCarty
D. J. Morrissey
J. E. Overall
R. H. Pentecost
J. K. Powell
E. W. Prince

Absent:

G. A. Charters
N. L. Danforth
G. G. M. Eastwood
R. Fricton
R. R. Gardner
R. B. Hurm
C. D. Lindwall
D. P. Michel
J. H. Pearson
R. G. Spangler

H. Schreier attended the meeting in the place of R. B. Hurm.

J. E. Irvine attended the meeting in the place of D. P. Michel.

Two visitors attended the meeting: H. E. Kirkland and W. J. Frair

The meeting was called to order by Chairman Powell, followed by self introduction of all present.

Old Business

Project 775. "The Principles of On-The-Machine Paper Moisture Measuring Systems." A written report from the absent R. B. Hurm was read. "It is with regret that our work load at Beloit has not justifiably permitted my attendance at the 14th Engineering Conference.

"I was actually late getting necessary correspondence to the manufacturers of moisture measuring equipment, a point which is the factor in it not being completed at this time. However, the ball is rolling on Project No. 775 and we should be pushing to reasonably soon completion."

Mr. Hurm's report also listed two possible papers for 1960 Conference:

"Instrumented Stock Preparation System," International Paper Co., Corinth, N. Y.
"Economics of Basis Weight Control," Howard Smith Paper Mills, Ltd.

Data Sheet Subcommittee. C. E. McCarty reported that his activity is no longer in the instrument field so he must resign as chairman. He recommended W. H. (Bill) Hebrank for committee membership.

The McGraw-Hill instrument list was reported to be available, but costly. The fee would be $10.00 per page for approximately 100 pages.

L. G. Good stated that ISA has a committee on Standards and Practices. He suggested checking this to see if ISA would allow symbols and definitions to be reproduced as Data Sheets, with credit to ISA. Chairman Powell is to receive a letter from L. G. Good regarding this.

Project 692. "Organization and Importance of the Paper

Process Instrumentation Committee

Mill Instrumentation Department." In the absence of R. R. Friction, a report was given by Vice-Chairman Prince. Copies of the questionnaire were submitted to the committee. It was considered satisfactory by the committee. It will be forwarded to TAPPI Headquarters for distribution.

TAPPI Magazine Question-and-Answer Column. Chairman Powell stated the need for more contributions, questions and answers, or questions alone.

TAPPI-ISA Relations. L. G. Good reported ISA interest in joint conferences and symposiums. He has their assurances on this and their philosophy that the events should financially break even if possible. ISA has scheduled one symposium on paper for 1960. This is in cooperation with the Southeastern ISA. The meeting was announced as the Sixth Annual Southeastern ISA Conference and Exhibit and First Pulp and Paper Division Symposium at Pensacola, Fla., April 27–29, 1960. Notices were distributed to those present.

It was stated that ISA contemplates 28 conferences between now and the end of 1967.

H. P. Fishwick had attended the last previous meeting of the Fox River Section of ISA. He reported that their proposed Symposium had been put off another year.

Chairman Powell will discuss TAPPI-ISA future conferences with the TAPPI Engineering Division people. Mr. Good stated that ISA would be happy to cooperate on a conference in 1961, 1962, or 1963 on a national basis. He pointed out that papers presented are eligible for review by the Transaction Board of ISA for publication as original work. Chairman Powell will check TAPPI policy on such papers.

New Business

14th Engineering Conference. Chairman Powell announced the Committee program for the 14th Engineering Conference.

15th Engineering Conference. Chairman Powell further announced the next conference would be in Jacksonville, Fla., Oct. 24–28, 1960. Papers were suggested as:

1. D. P. Michel—Paper in progress.
2. Instrumented Stock Preparation System—International Paper Co., Corinth, N. Y.
3. Economics of Basis Weight Control—Howard Smith Paper Mills, Ltd.
4. Report on Project no. 692.
5. Report on Project no. 775.

The chairman further requested papers be prepared, and received agreement from those asked, as follows:

6. McCarty—Products Selection for Warehousing
7. Couture—Coaters
8. Dawson—A Consulting Engineer's Viewpoint (Instrumentation)
9. Harman—Subject later
10. Connors—Subject later
11. Lavigne—Subject later
12. Fishwick—Subject later
13. Morrissey—Subject later (possibly consistency regulator evaluation)
14. Overall—Subject later
15. Clarke—Subject later
16. Good—Subject later
17. Pentecost—Subject later

The Steering Committee will evaluate the papers for presentation or publication.

It was discussed that members can obtain papers from other people to count as their papers. For instance, Jim Overall pointed out the background in Union Bag-Camp Paper Corp. for a paper on "Economic Justification of an Instrument Department."

The Committee agreed to have four papers at the 1960 Conference. We had three at the 1959 Conference.

Committee Membership. The chairman announced his objective to obtain six to ten additional mill men for the committee in the next year.

Interim Meeting. The Committee agreed upon a Spring Meeting on Thursday, April 7th at the Pittsburgh Airport Hotel. No meeting is scheduled during the National TAPPI New York Meeting in February.

Conference Meeting Time. It was agreed that the 6:00 p.m. meeting time was the best known and would be used again.

R. D. Clarke, *Secretary*

Alkaline Pulping Committee

Chairman Limerick opened the meeting of the Alkaline Pulping Committee at 2:00 p.m. Nov. 3, 1959, at the Robert Meyer Hotel Jacksonville, Fla., and welcomed the members.

1. On motion by D. Wetherhorn, seconded by K. D. Running, the minutes of the last meeting were accepted without a reading.

2. The current conference plans were reviewed:

a. Chairman Limerick complimented all committees on a very fine job and a well planned meeting.

b. Mr. Rice reported for the local arrangements committee mentioning particularly the cooperation of the local mills in the area.

c. Mr. Running reported on the technical program for the meeting.

d. Registration was set at $12.50 for members, $17.50 for nonmembers. The $12.00 fee for the ladies is equivalent to the out-of-pocket costs for their program.

3. On motion by V. Woodside, seconded by D. Wetherhorn, the February meeting was set at 2:00 p.m. Sunday at the Commodore Hotel, New York, N. Y.

On a motion by D. Wetherhorn, seconded by A. W. Pesch, the February session was set for half day of four papers.

On motion by Mr. Wetherhorn, seconded by Mr. Pesch, a preference was expressed for Tuesday or Wednesday afternoon for the session.

H. Y. Charbonnier moved, seconded by Mr. Running, the chair appoint a three-man nominating committee to suggest officers for the coming year.

4. The 1960 fall conference was discussed at some length. Meeting time and place was reviewed.

After some discussion, it was left to Chairman Limerick to appoint local arrangements committees, and the program chairman. These groups are to be from the West Coast. A. H. Wickett of Weyerhaeuser commented on the proposed meeting.

Considerable discussion of noon luncheons, banquets, and the hospitality hour ensued. Noon luncheons were generally favored. Very little interest was shown in holding a banquet. Hospitality hours were discussed at some length. The consensus of the group was against asking a supplier to support a hospitality hour and to avoid any chance of

13th Alkaline Pulping Conference, Alkaline Pulping Committee meeting, J. McK. Limerick, Bathurst Power and Paper Co., chairman

having suppliers of competitive materials vying with each other in this area. Generally, the problem was unsolved, and was left with the general agreement that such affairs should be voluntary.

Mr. Charbonnier moved and Mr. Wetherhorn seconded, the semichemical Committee be invited to present a half-day session at the 1960 meeting. This motion was passed.

5. The 1961 meeting was set for Houston, Tex., in the Rice Hotel on November 1 to 3.

6. The 1962 conference was discussed at some length. This was broken down first by area and it was voted first to stay in the southeast. Possible location was discussed covering Richmond, Mobile, Savannah, Birmingham, and others. On a show of hands, eight voted for Savannah and three for Mobile.

7. Resignation of D. J. MacLaurin was regretfully accepted and his suggestion for replacement considered. E. F. Thode and R. B. Kesler of the Institute were suggested. T. T. Collins was suggested for reinstatement. Chairman Limerick will consider the suggestions and make appropriate appointments.

8. D. C. Gillespie reported for the Monograph Committee: The project has been given official status and organization is underway. The committee is presently looking for an editor and an editorial board for the monograph. Quite a few people have been contacted without success. It is planned the alkaline pulping committee will work with the editor, when he is selected.

9. Mr. Wetherhorn reported for the Testing Subcommittee: the Pascoe-Borlew method was turned down by the standards committee. Some discussion of the methods followed. This method is to be reworked and resubmitted by Mr. Kesler as a part of the revision of T625.

Green and white liquor analysis method T624: To date no information from committee. Messrs. Limerick and Wetherhorn will follow up.

Activity test for black liquor: Mr. Kesler will prepare copies of the method for the subcommittee. As soon as the committee agrees on the proposed R. C. method, copies will be supplied to the full committee.

10. B. Borlew reported for the committee on the chemistry of the sulfate process and digester corrosion: He mentioned a recent work indicating a small amount of polysulfides as damaging to steel and a large amount of polysulfides as passivating. The committee is watching current problems, but not actively working on the problem.

Those present were:

R. L. McCray
E. S. Rice
B. Stengle
P. H. West
R. B. Keler
P. L. Gilmont
K. D. Running
D. Wetherhorn
H. Y. Charbonnier
R. L. Miller
R. R. Fuller
W. E. Hariland
R. H. Stevens
V. Woodside
D. E. Gillespie
H. O. Teeple
P. B. Borlew
A. W. Pesch
J. McK. Limerick
R. C. MacDonald
A. Hugh Wickett

Robert R. Fuller, *Secretary*

Corrugated Containers Division—Industrial Engineering Committee

The meeting was held in Room 4 of the Jung Hotel, New Orleans, La., on Tuesday, Sept. 15, 1959.

Attending:

G. Austin, Mead Containers, Inc.
F. H. Cloud, American Boxboard
A. J. Dannenberg, Cornell Paperboard Div. of St. Regis
J. McGovern, Chippewa Paper Products
H. H. Kroll, Grand City Container
C. B. Lawler, Union Bag-Camp Paper Co.
W. C. Kline, Container Corp. of America, *chairman*
T. W. Carroll, Owens-Illinois, *vice-chairman*
R. S. Owen, R. S. Owen & Co., *secretary*

Guests:

F. Came, Union Bag-Camp Paper Co.
J. Duffy, Container Corp. of America

Members of the committee who were absent:

R. L. Jenk
E. Rohde
L. Wightman
G. Williams
R. Emery

Chairman Kline reviewed the Steering Committee meeting of the morning during which the Industrial Engineering Committee had been asked to have $^1/_2$ day of the fall meeting in 1961. Four papers are required from this committee for the conference.

The committee should initiate and develop projects. Such an undertaking is under the control of TAPPI in that each project must be approved and receive a serial number and be published in TAPPI.

The following topics were suggested:

1. Waste—measure and control.
2. Educational program for supervisors in time standards.
3. Use of films by the I.E.
4. Reporting of productivity, control of proper working force numbers, and administration of measured performance.
5. Economics of replacing equipment.

After a discussion of these topics, during which it was evident that each topic was of real current interest and during which the clock moved beyond adjournment time, it was decided to refer final selection to the committee officers.

The members regretfully accepted Chairman Kline's statement that he must resign. In accordance with Corrugated Containers Division custom, the other officers moved up and a secretary was elected. The new officers:

T. W. Carroll, *chairman*
R. S. Owen, *vice-chairman*
F. H. Cloud, *secretary*

A meeting of the officers is to be held September 16.

The chairman of the Corrugated Containers Division of TAPPI may be asked to write a letter to each member company, encouraging them to have a representative join with the members of this Committee to carry out their declared intention to operate as an effective unit of the TAPPI organization.

Messrs. D. J. Jordan, Hygrade Containers, Ltd., Montreal, Can., and H. A. Buckley, Standard Paper Box, Montreal, Can., applied for membership in the Committee and were accepted.

R. S. Owen, *Secretary*

Deinking Committee

A meeting of the Deinking Committee was held at the Roger Smith Hotel, Holyoke, Mass., on Oct. 7, 1959.

The meeting was opened by Doyle Boggess, chairman, and the minutes of the February meeting were read and approved.

Topic 1

Deinking Questionnaire (No. 732). Answers received will be published and circulated to answering members and committee. Forty-six questionnaires were sent out; 42 are doing deinking four were negative.

Summary: Most mills do not need a standard method of testing for contamination and therefore, project would not be as valuable to them as suppliers of wastepaper.

Questionnaire: Reveals no standard method of deinking.

Summary: No standard method needed since many methods are used and all are more or less satisfactory.

Following a discussion on "what is deinkable or what can be established as standard method of determining deinkability," it was decided to handle through TAPPI circulation, return and compile control TAPPI data sheet.

Resolution: Chairman to appoint subcommittee to recommend a procedure or procedures leading to Routine Control Methods or methods for determining deinkability of wastepaper.

Seconded and passed:

The subcommittee appointed Merle Wilkins, chairman, Al Alteri, Tileston & Hollingsworth, vice-chairman, and John Wendell, Tileston & Hollingsworth.

National TAPPI to send to Merle Wilkins the results and answers to Questionnaire 732.

The Routine Control Method or Methods would be recommended for use by wastepaper suppliers and by deinking plants to determine if furnish is satisfactory for use, by procedure selected for (a) themselves, (b) suppliers, (c) chemical and adhesive suppliers, and (d) others.

Topic 2

Deinking Practices Project No. 733. Merle Wilkins reported that Part "A" was circulated but had no knowledge of status.

Herb Teeple reported that members had sent in replies, but that these were missing at that time.

These reports are to be forwarded to the secretary for inclusion in this report.

Topic 3

Sticky materials. (Re Project Appropriation request). Report by Al Alteri.

1. On resubmission of the revised request to nine research centers, 4 proposals were received. Prices quoted ranged from $3000. to $8000. The times required ranged from 3 months to 1 year. One center did not choose to quote and four have not replied as yet.

The committee will vote on the acceptance of one or more proposals prior to resubmission of project to the Project Appropriation Committee.

2. The rewritten project is to be circulated to members. The plan is to have the project ready for March, 1960 and vote by the Project Appropriation Committee.

3. The broadened scope of project addendum was sent to G. T. Renegar, Container Corp. of America who referred it to J. T. Higgins, Ohio Box. Mr. Higgins replied he would advise this committee following meeting of his group. No reply has been received to date.

4. On the identification of material—the committee is not interested in chemical compound or its name except that it may be identified as to category.

5. A copy was sent to Foster Doane to familiarize him with project.

Summation

Resolution: Vote of confidence in committee which was to delay the proposal until the cylinder board group can be contacted and requested to enter joint agreement for requesting a Project Appropriation. Seconded. ayes 7. Nayes 7. Chairman cast deciding vote with ayes. If Cylinder Board Committee does not join with us on this project, we will then proceed on our own.

Topic 4

Program Advisory Committee—John Clouse. The formation of an expanded Program Advisory Committee to help the program chairman in the preparation of the technical program was announced.

This committee will consist of six rotating members plus the current officers of Deinking Committee. The retiring Deinking Committee chairman becomes senior member while the Program Advisory Committee chairman retires but remains a member.

Chairman of Program Advisory Committee is to be appointed by the Deinking Committee chairman.

Two additional members were appointed to bring committee to required number of six. These are: M. Wilkins, term: 6 years; O. P. Fussell, term: 5 years. The vote, seconded, was unanimous.

Topic 5

Conferences.

Chairman Boggess led a discussion on the question whether the Committee should sponsor annual or biannual conferences.

The deinking section of paper industry is a very important factor in determining pulp costs. It represents a large portion of the wastepaper utilization group. Twenty-five per cent of the furnish on a national basis is wastepaper and what affects the deinking section, affects the entire paper industry.

It was suggested the technical programs should be diversified by inclusion of information on basic deinking principles.

The resolution was to retain annual meetings. The motion was seconded and passed unanimously.

New Business—1960–1961 Conferencss

General Conference Chairman, 1960 Conference: James D. Allen, Bergstrom Paper, Neenah, Wis., Appointed by Chairman.
Program Chairman, 1960 Conference: Robert Kinne, Oswego Falls Corp., Fulton, N. Y., Unanimously elected.
Program Chairman, 1961 Conference: George Sisler, Bergstrom Paper, Neenah, Wis., Unanimously elected.

The conference sites considered for 1960 were:

Kalamazoo, Mich.—four deink mills
Appleton, Wis.—four deink mills—The Institute of Paper Chemistry
Washington, D. C.—printers
York, Pa.—two deink mills

Appleton, Wis. was selected by committee vote for 1960. York, Pa., for 1961.

The preferred dates of conference are:

1960—1st. October 4, 5, 6
2nd. September 21, 22, 23
1961—1st. October 4, 5, 6
2nd. October 25, 26, 27

Committee Registration

A form useful for formal application for Deinking Committee membership will be supplied by TAPPI Hq. The committee secretary will mail the approved form to prevent committee members and compile the results.

Annual re-registration is to be required and is to be handled by the secretary.

Chairman Boggess closed meeting with praise for important work done and decisions made by the Committee members. He extended his thanks to all attending.

A. J. Felton, *Secretary*

TAPPI-ASTM Technical Committee on Petroleum Wax

General Committee Meeting

The General Committee met as Technical Committee M of ASTM at 3:30 p.m. on Oct. 14, 1959 in the French Room of the Sheraton-Palace Hotel, San Francisco, Calif., M. W. Kane, chairman.

The meeting was called to order by the chairman, Mr. Kane. There were 15 members present or represented. Eight section members and visitors were also present.

The minutes of the Feb. 25, 1959, meeting in New York were approved as read.

The following sections made verbal summary reports to Technical Committee M (Summaries of the section activities are appended to these minutes.):

Section I—W. R. Turner, Chairman. This report included a recommendation that a revised draft of methods ASTM D 1320–57 T and TAPPI T 644 m-58, as authorized by vote and letter ballot of the section, be submitted to letter ballot of the Joint Technical Committee.

Section II—E. A. Pullen, Chairman

Section III—L. T. Mehlhorn, Chairman

Section IV—R. W. Dannenbrink, Chairman. This section did not meet at this session, but the chairman announced a meeting for February, 1960. It is contemplated at that time to consider advancing the method "Odor of Petroleum Wax"—ASTM—for information only (1957) and T 654 sm-58—in both organizations.

Section V—F. A. Brill, Chairman. It was suggested that an article on "Determination of Oil in Parraffin Waxes," by C. W. Leighton, *Anal. Chem.* 22, 1168 (Sept., 1950), be studied by the group prior to the next meeting.

Section VI—For J. Walker, chairman, by D. I. Walker.

Section VII—For W. Y. Winey, chairman by H. W. Moyer.

Section IX—S. W. Ferris, Chairman. *Motion* to accept all of the above reports was seconded and *passed.*

The chairman announced that a standard sheet would now be available from U. S. Testing Co. in three regular widths: $2^1/_4$-in., 5-in., 9 in. It is expected that this will be suitable for test work on blocking, sealing, laminating, gloss, friction, etc.

Mr. Kane presented a request from ASTM D-2 Advisory Committee for Technical Committee M to take jurisdiction over petroleum products tests now under the jurisdiction of ASTM Subcommittee I of D-2. This includes:

Carbonizable substances in mineral oil	D 565
Penetration of petrolatum	D 937
Congealing point of petrolatum	D 938–49

Technical Committee M (Joint TAPPI-ASTM) had requested return of D 612–45 on Carbonizable Substances in Paraffin Wax to Subcommittee I and asked for jurisdiction over D 938–49.

Motion was made, seconded, and *passed* to submit a proposal to letter ballot of Technical Committee M that D-2 Advisory Committee be advised that Technical Committee M is willing to take over the functions and standards of Subcommittee I, *excluding* oils.

The chairman reported that Tech M Advisory Committee in meeting on Feb. 25, 1959, had instructed him and the secretary to send out to the mailing list a proposed format for change in the organization of this committee. This would reduce the number of sections and provide for more efficient use of the membership. This was to be completed in time to be presented to the October meeting. A proposal was sent out Aug. 20, 1959, and comment received indicated general approval of the idea.

Motion was made, seconded and *passed* referring the proposed format of organization to the Advisory Committee (Tech M) for review and changes felt by them to be desirable and then to submit the proposal to Tech M for letter ballot.

The secretary announced that the next meeting would be in conjunction with the 1960 TAPPI annual meeting at the Commodore Hotel in New York, Feb. 22–25, 1960.

A *motion* to adjourn was passed. The meeting adjourned at 4:45 p.m.

D. I. Walker, *Secretary*

Attendance at Meeting of General Committee Sheraton-Palace Hotel, San Francisco California—October 14, 1959

M. W. Kane, KVP Co.
D. I. Walker, Standard Oil Co. (Ind.)
T. Gordy, Continental Oil Co.
H. C. Moyer, Sinclair Research
M. V. Hunter, California Research
R. D. Clark, California Research
W. J. Yates, Shell Oil Co.
R. W. Geiser, Quaker State
R. W. Dannenbrink, Marathon Corp.
H. H. Coffman, Bareco Wax Co.
F. A. Brill, Atlantic Refining Co.
C. W. Layton, Standard Oil of California
F. J. Higgins, Continental Oil Co.
E. A. Pullen, Union Oil Research
L. T. Mehlhorn, D-X Sunray Oil Co.
A. C. Smith, Jr., Atlantic Refining Co.
S. W. Ferris, Sun Oil Co.
R. L. Murphey, Texaco
E. W. Gardiner, California Research
M. A. Joanen, Sinclair Refining Co.
D. Aziz, International Wax
D. L. Patrick, Continental Oil Co.
L. T. Crews (for J. A. Bolt), Standard Oil Co. (Ind.)

Section I—Strength Tests

Chairman: W. R. Turner. *Subsection A—Tensile Strength.* Chairman: W. R. Turner.

The results of the recent letter ballot changes in the text of test methods ASTM D 1320–57 T and TAPPI T 644 m-58 were announced—18 voted, 18 accept. These would incorporate a statement indicating that the specified reproducibility is questionable and under study and would delete reference to a standard wax sample.

The chairman reported on his review of previous work on the effect of variables. The committee asked the chairman to review the method for possible editorial changes which might eliminate any uncertainties in regard to test conditions.

A graphical analysis of the 1958–59 round robin data confirmed poor reproducibility but good repeatability, indicating bias within the individual laboratories. Preliminary work by four laboratories using standard wire samples to calibrate their tensile strength machines was discussed. Ten laboratories agreed to participate in an extension of this work.

Subsection B—Breaking Strength Subsection Chairman—J. R. Wright.

The TAPPI Standards Committee is now voting on the modulus of rupture test method. If the vote is favorable, it will probably be published in the December or January issue of *Tappi.*

Section II—Flow Tests

Chairman: E. A. Pullen.

E. A. Pullen replaced B. G. Post as chairman of this section. R. D. Schieman was appointed secretary.

The revisions to ASTM D 1321–57 T and TAPPI T 639 sm-58 "Needle Penetration of Petroleum Wax" as recommended by Section II have been approved by ASTM Committee D-2 and have been submitted to the TAPPI Standards Committee. These revisions include extension of the scope to 150 units, revision of the precision section, and several procedure clarifications. Suggestions received from Mr. McCue (Chairman, IP Subcommittee 8 on Petroleum Wax) for simplifying the needle, and from Mr. Clark (Chairman TAPPI Standards Committee) were considered.

Six laboratories had reported results for the 1959 round robin on friction coefficient of wax. Ten waxed paper samples were supplied by Marathon for measurement of static and kinetic friction coefficients of their high gloss sides (outer surface of roll) on two different days. The same waxes used on the Marathon-coated papers were distributed for coating in the individual laboratories on two different days for measurement of static and kinetic friction after one and seven days elapsed time. Both air-cooled and water-cooled specimens were to be prepared.

Preliminary analysis of the friction coefficient data was made for the Marathon-coated samples and for one set of

individually coated samples. Although all laboratories rated the samples in the same order, and the repeatability appeared to be acceptable, the reproducibility between laboratories was poor. Comparison of water-cooled kinetic friction coefficients for this series with the series in 1958 showed no bias for the five laboratories that participated in both.

It was recognized that the 10 g. per cm. load used in the test method could lead to variations. The extent of deformation of the waxed surface would be expected to vary with the length of time the sled is in position before testing, and could increase the static friction coefficient. Scuffing of the waxed surface during testing could affect the kinetic friction coefficient. The section decided to retain the test conditions in order to simulate conditions found in field applications, and because useful correlations based on them had already been developed.

In order to eliminate the factors of shape, weight distribution, and point of thread attachment to the sled, the chairman agreed to make several identical sleds and distribute them to the participating laboratories.

Section III—Stability Tests

Chairman: L. T. Mehlhorn.

The Proposed Test Method for Peroxides in Paraffin Wax, containing editorial changes agreed upon at the last meeting plus minor changes in wording of the scope, was discussed.

Data reported by nine laboratories participating in the recent round robin showed repeatability and reproducibility, respectively, of 1.9 and 3.9 for paraffin waxes and microcrystalline waxes having peroxide numbers in the 0 to 10 range. Three laboratories which found no peroxides in the samples in the low peroxide range will be supplied with additional samples for further work. The committee felt that their determinations indicated a possible need for changes in the wording of the procedure and more care in preparation of the potassium iodide solution.

The committee also voted to incorporate a written suggestion for more specific wording of the procedure in 5b of the method. The chairman was authorized to edit the method incorporating these changes and to submit it to letter ballot of the section.

Section V—Composition

Chairman: F. A. Brill.

The discussion and work of this committee covered some of the methods which would fall within the scope of this committee if the activities of Subcommittee I of D-2 were transferred to Section V of Technical Committee M, as suggested by D-2 Advisory. This is summarized below.

D 87–57: Melting Point of Paraffin Wax. A letter ballot on changes in thermometers 14°C. and 14°F. resulted in 13 ballots returned, 13 affirmative, 0 negative, 0 not voting. The results have been reported by letter to D-2.

The chairman had reviewed the proposed draft of TAPPI T 630 m–58, on request, and approved it for printing as being technically equivalent to D 87–57.

D 612–45: Carbonizable Substances in Paraffin Wax. The Section V request to return jurisdiction over this method to Subcommittee I of D-2 was reviewed. An alternative to the proposal, suggested by D-2 Advisory, would be the transfer of Sub. I entirely to Tech M. Decision in the matter has been placed in the hands of Tech M by D-2 Advisory.

D 938–49: Congealing Point of Pharmaceutical Petrolatums. The question of jurisdiction over this test method is still to be decided by Tech M as in the case of D 612.

Anticipating the possible transfer of jurisdiction, Section V conducted a letter ballot on the extension of the title and scope of the method to include petroleum waxes. Fifteen ballots were returned, 15 affirmative, 0 negative, 0 not voting. It is therefore recommended that Tech M (in the event of having jurisdiction) adopt the changes in method D 938–49, subject to letter ballot, for submission to D-2, the letter ballot to contain also a precision statement to be prepared by L. T. Crews and J. D. Tench based on cooperative test data on petroleum waxes obtained in Section IX. The precision statement with supporting data will be forwarded to the secretary of Tech M.

D 127–49: Melting Point of Petrolatum and Microcrystalline Wax. It was voted that the results of a round robin of 10 laboratories for precision determination be analyzed by the chairman and a precision statement prepared in D-2 terms for submission to letter ballot of Section V. The round robin covered two petrolatums and three microcrystalline waxes.

D 721–56T: Oil Content of Petroleum Waxes. Two possible revisions of D 721 aimed at precision improvement at the low oil content level were discussed. Immediate interest centered on a method using the present apparatus for D 721 and described in Atlantic Refining Co. memoranda 0054 and 0060. The former was distributed with the minutes of the February meeting and the latter was distributed at the section meeting. R. W. Dannenbrink, L. T. Mehlhorn, and J. A. Wood volunteered to try the revision on their own waxes. It is hoped that other section members will do likewise and submit comments in time for discussion at the next meeting of Section V. A report by Mr. Sears, chairman of IP Subcommittee No. 15 has been circulated to the section members. It is a critique of the precision of D 721 and shows an improvement merely by the introduction of a semimicro balance.

The section discussed further the 15% oil content limit in the scope of D 721. The chairman supplied copies of a study of the subject by Dr. Mazee of the IP, and a report, dated June 10, 1943, by L. L. Davis of Continental Oil Co. was distributed with the previous minutes. The chairman requested that section members study these documents and circulate any comments they might have so that a definite decision as to the limitation of the scope could be arrived at at the next meeting of Section V.

A letter ballot on changes in the thermometer for D 721 resulted in 13 ballots returned, 12 affirmative, 0 negative, 1 not voting. This was reported to D-2.

Section VI—Blocking

Chairman: J. Walker.

Arrangements have been made for the United States Testing Company to take over the distribution of both the "High Blocking Range" and "Low Blocking Range" standard reference waxes.

The present Precision Section of the method was obtained by cooperative work on the two standard waxes, both of which have fairly sharp blocking points. Some paraffin waxes are reported to have less sharp blocking points, and consequently the stated precision cannot be attained with such waxes.

The chairman will circulate a questionnaire to members of Section VI in order to get expressions of whether to carry out another cooperative program to establish precision data on a broad range of paraffin waxes. The possibility will be explored of re-phrasing the Scope of the method or adding a note to the Precision section explaining that the presently stated precision pertains only to paraffin waxes with sharp blocking points, and that it cannot be expected to get as good precision with waxes with poorly defined blocking points.

It was announced that the Marathon Corp. is in a position to supply the Marathon blocking plate and that the United States Testing Co. is supplying the Esso blocking plate.

Section VII—Sealing and Laminating

Chairman: W. Y. Winey.

H. C. Moyer served as chairman in the absence of W. Y. Winey.

The Section considered two main issues: 1. future work

on a laminating strength test as yet unpublished; and 2. future work on the published sealing strength test.

In the case of the laminating strength test, past results and problems were reviewed and several new ideas were discussed which should minimize past problems. These ideas will be investigated by various members before the February meeting to determine general suitability and provide a reasonable basis for setting up further round robin testing. Results of the initial phase of the laminating strength work have been encouraging. If uniformity of specimen preparation can be improved, the section should be able to accomplish its goal: 1. to evaluate paper from the new source (U. S. Testing Co.,) and 2. to provide precision data necessary to advance the test status.

It was agreed that the section should aim at establishing available standard waxes. These would be helpful in minimizing such problems as variations in paper stocks with age and possible variations in paper procurred at future times.

Two waxes for the current round-robin test will be furnished by Sinclair Research, and specific instructions will be mailed to all members.

Section IX—Nomenclature

Chairman: S. W. Ferris.

At the February, 1959, meeting Section IX tentatively adopted definitions for paraffin wax, semimicrocrystalline wax, and microcrystalline wax. Briefly, this involves the position of a given wax on a chart having Congealing Point, F (ASTM D 938) as the abscissa and refractive index at 212°F (ASTX proposed) as the ordinate.

The reference line on this chart is a straight line drawn through the values for pure normal paraffins. Petroleum waxes falling within specified distances (on the R.I. axis) from the reference line are "paraffin waxes." Petroleum waxes falling farther away are semimicrocrystalline waxes if the kinematic viscosity at 210°F, is below a stated value, and microcrystalline waxes if the viscosity is at or above the stated value.

There was extended discussion of the experience which members had had with the system since the last meeting. The following modifications were adopted:

1. The straight line separating paraffin waxes from semimicrocrystalline and microcrystalline waxes shall be drawn through a point 0.007 R.I. units above the reference line at 100°F. congealing point, and a point 0.003 above the reference line at 180°F. congealing point. (Previous values were 0.005 and 0.003, respectively.)

2. The value of the separating viscosity between semimicrocrystalline waxes and microcrystalline waxes shall be 10.0 centistokes at 210°F., with microcrystalline waxes characterized by a value of 10.0 or higher. (The previous value was 8.0 cs.)

The effect of these two changes is somewhat to increase the percentage of low melting waxes characterized as paraffins, and to require that higher percentages of microcrystalline wax be added to a paraffin before the blend becomes "semimicrocrystalline."

The chairman reported that on May 27, 1959, he had sent copies of much of the section's correspondence to C. F. McCue, chairman of Institute of Petroleum Subcommittee 8 (Wax), who is anxious to have TAPPI-ASTM and IP in agreement on matters of nomenclature. The chairman presented a letter dated June 3, 1959, which was circulated to section members. Mr. McCue took the position that, in lieu of attempting to define words whose meanings have ceased to be precise, it might be better to refer simply to "petroleum waxes," and to differentiate by means of a "paraffinicity index" based on the R.I.-congealing point relationship. While it was felt sound by some that a "paraffinicity index" is valuable for research work, it was agreed that for over-all producer-consumer use it would be harder to introduce and of less utility than definitions.

The definitions as developed to this point were unanimously adopted. The chairman was instructed to put all definitions into suitable form for a letter ballot by Section IX, with the results to be reported to Technical Committee M at its next (1960) meeting.

D. I. Walker, *Secretary*

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Eleventh
Testing Conference
of the
Technical Association
of the
Pulp and Paper Industry
Pantlind Hotel
Grand Rapid, Mich.
Sept. 27–29, 1960

ENGINEERING DIVISION

Questions and Answers

Good engineering questions are solicited as well as answers or alternate answers to the published questions. Material should be sent to TAPPI Headquarters, marked for the attention of H. O. Teeple. The items contributed will be forwarded to the Question and Answer Committee for processing. If comments are to be contributed, please refer to the question number.

*(58) *Question* (**Grounding in a Three-Phase Generating Plant**): **Is it good practice to ground steel framing of the plant, as well as instrument casings and transformer tanks, etc., on the same ground plate as generator neutrals?**

*(*58.1*) *Answer:* This is permissible and is the practice in some plants. But it is considered better practice to have a separate ground for the generators. No matter how much care is taken to keep the resistance of the generator ground as low as possible, it is practically impossible to prevent the voltage drop in the ground from reaching at least 200 volts on dead short-circuit. In case the same ground is used for the station, this voltage backs up all over the plant, and anyone touching any apparatus may receive a shock, and delicate instruments be damaged by this tension. Furthermore, there is always some chance, although remote, that the ground may accidentally dry out or the connection to the plate may become corroded and broken, in which case a short-circuit in one phase may give full-line voltage on the whole grounding system of the plant, with great danger to life and apparatus.

*(59) *Question* (**Condenser-Tube Scale**): **When water is simply passed through a condenser once, rising about 10°F., and then wasted back to the river or other source, does scale build up?**

*(*59.1*) *Answer:* In most cases, no scale forms, but when water is not in constant motion, volume is too small, or speed of circulation is too low, heat gets a chance to work on the calcium carbonate (plus magnesium carbonate, silica, iron, and organic matter) and this product, stable in cold water because entrained CO_2 has made the water acid, precipitates out as the CO_2 leaves the water. It is also possible that well water will contain an excess of carbonic acid over that necessary to keep the calcium bicarbonate in solution, and thus become corrosive. Resulting scale is a mixture of calcium carbonate and rust. Algae and bacteria are another problem entirely.

*(60) *Question* (**How Are Elevator Car Safeties Released?**): **The question has been raised among some of our men of proper procedure when releasing safeties on our elevator cars in case they are set from overspeed. I would appreciate knowing how this should be done.**

*(*60.1*) *Answer:* The way to release safeties on elevator cars depends largely upon the type of safety used. For some types it is only necessary to raise the car a short distance and the safeties will release themselves. In all cases, on a drum-type machine it will be necessary to see that the hoist ropes are not slack before moving the machine with the motor. If the hoist ropes are found to be slack, they also may be misplaced in the drum grooves. In such cases it is necessary first to adjust the hoist rope then slowly take up the slack by moving the machine by hand.

Where wedge-clamp type safeties are used, after strain has been taken on the hoist ropes to support the car, the safeties are released with a tool operated through a hole in the floor of the car. In some cases this tool consists of a gear on a shaft; in others a special type of lever is used. After the safeties are released, the governor cable must again be attached to the carrier on the car and attention given to the overspeed governor to see that it has freed its rope.

*(61) *Question* (**Steam-Bound Feed Pump**): **Our 2800-r.p.m. boiler-feed pump takes water under 15- to 20-ft. suction head and discharges at 175 to 180 lb. Feedwater temperature runs 208 to 220°F. At times the pump becomes steambound and either burns the packing or causes it to shrink away from the shaft.**

*(*61.1*) *Answer:* Insufficient suction head at the pump eye is probably the cause. When demand for feedwater increases rapidly, the head at the pump eye falls below the vapor pressure of the water, permitting the pump to become steam bound. Possibly the connection between pump and feeder heater is very long and under size. Velocity of water in the suction line should be under 6 ft. per sec. 15-ft. head should be sufficient with 212°F. water, but isn't if the water reaches 220°F.

*(62) *Question* (**Turbine Exhaust Pressure**): **Our turbine operators compute absolute backpressure by taking the difference between barometric pressure and the mercury-column vacuum gage. Would either of the following two other methods be preferable? I am thinking of simply reading the absolute-backpressure mercury-column gage, or by observing the temperature of the exhaust steam and determining absolute backpressure, in inches of mercury, from the steam tables. I know these three methods do not agree.**

*(*62.1*) *Answer:* While not the most accurate, the simplest method is to read temperature of exhaust steam and to determine exhaust pressure from the steam tables. This gives more consistent, hence more readily comparable, results, probably because it is easier for an operator to read an exhaust-hood thermometer to an accuracy of 1° F. (corresponding to about 0.03 in. Hg) than it is for him to read a barometer and vacuum gage to the same degree of accuracy. At full load, the temperature in one case showed 0.06 in. Hg higher vacuum than the average of two mercury columns connected at the condenser inlet flange. At 30% load, the difference dropped to 0.

*(63) *Question* (**Varying Speed of a Compound Motor**): **Can the speed of a compound-wound motor be adjusted by the use of a variable resistance connected in series with the shunt-field winding as in shunt-wound motor?**

Note: Questions and answers marked with asterisk (*) are reproduced courtesy *Power* magazine.

*(63.1) *Answer:* The speed of a compound motor cannot be adjusted by introducing a variable resistance in the shunt-field winding, and operate as a compound machine, as with a shunt motor. This is due to the ampere-turns of the series winding becoming more effective as the ampere-turns of the shunt winding are reduced. Where a drive requires a compound motor during the starting period and shunt-field control after, the series winding is cut out of circuit before introducing resistance into the shunt-field circuit. Such conditions are found in elevator and printing-press drives, etc.

*(64) *Question* (**Coefficient of Expansion of Firebrick**): **What is the coefficient of expansion of firebrick?**

*(64.1) *Answer:* Experiments have shown that the coefficient of expansion of firebrick decreases with temperature rise, but an average coefficient of linear expansion within the range of temperatures ordinarily attained in boiler furnaces would be about 2.7×10^{-6} per °F.

*(65) *Question* (**Power Input to Induction Motor**): **How is a 10-hp., three-phase, 440-v., induction motor tested to determine if it is underloaded with an ammeter?**

*(65.1) *Answer:* An ammeter reading of an induction-motor load is of little import unless the power factor is known. Since the power factor of an induction motor decreases as the load is reduced, the current will not be reduced in proportion to the load. An induction motor operating at 50% load will take approximately 80% of the full-load current, but the power factor will be in the neighborhood of 0.70, where at full load it is about 0.87. The most satisfactory way to measure the power input to an induction motor is with a polyphase wattmeter, and then allow 900 w. per horsepower output, to obtain the mechanical load on the motor. About the only thing that an ammeter would show is whether the motor is overloaded or underloaded.

*(66) *Question* (**Testing with Air Pressure**): **Is air pressure as reliable as hydrostatic pressure for testing the tightness of piping, boilers, or other pressure containers?**

*(66.1) *Answer:* When the test pressure can be held, testing with air pressure is fully as reliable an indication of strength and tightness as testing by hydrostatic pressure. Original testing by air pressure alone is dangerous, for in event of rupture of the pipe or vessel under test, the rapid expansion of high velocity of the escaping air and recoil of the vessel may have the effect of a destructive explosion. For the same reasons serious damage has frequently resulted in making hydrostatic tests of vessels that were partly filled with air. Tests of strength should first be made with hydrostatic pressure 50% in excess of the allowable working pressure. As air is more searching of leaks, the joints of piping and containers for compressed air or gases may be more thoroughly tested by air pressure, but in cases where it is desirable to insure against an explosive effect, testing by air pressure should be preceded by a higher hydrostatic pressure.

*(67) *Question* (**Reactive Factor**): **What is the reactive factor of an alternating-current system, how is it determined, and what relation has it to the power factor?**

*(67.1) *Answer:* The reactive factor of an alternating-current circuit is the sine of the angle of lag or lead between the current and voltage. If the power factor is read from an instrument or calculated by dividing the watts by the volt-amperes, reference can be made to a table of natural sines and cosines and find the sine of an angle corresponding to the cosine that is the power factor. For example, if the power factor is 0.86, this is the cosine of a 30° angle and the sine of 30° is 0.5, therefore the reactive factor is 0.5 when the current is out of step with the volts by 30°. When the current and volts are in phase, the power factor is 1.00 where the reactive factor is 0. Another way of determining the reactive factor is by the formula:

$$\text{Reactive factor} = \sqrt{1 - (\text{watts/volt-amperes})^2}$$

The volt-amperes times the power factor equals true watts, where the volt-amperes times reactive factor equals the reactive component of the volt-amperes, sometimes called magnetizing watts, that is being transmitted back and forth through the circuit doing no useful work.

Unanswered Questions

(44) *Question:* **Most magnetic starters drop out at 55 to 65% voltage and the voltage will drip whenever a fault occurs on an electrical distribution system. How do we keep vital equipment which is started by low voltage magnetic starters from dropping out when the voltage dips? Is there a standard time-delay under-voltage protection system available?**

(45) *Question:* **Are the electrical manufacturers going to make the old 60 in. deep medium voltage starters available for our industry to purchase?**

(54) *Question:* **For differential protection of a delta connected alternator, is it considered better practice to provide for winding protection only (six current transformers and three single-phase relays) or to include protection on the line side of the breaker (nine current transformers and three relays)?**

(55) *Question:* **In a small paper mill a recent fault destroyed a 4000-amp., 440-v. air circuit breaker. This breaker was the main supply breaker for the mill from a 3000-kva. utility transformer. There are only the 2.5 times full load current fuses on the high side of the transformer. To re-establish service the breaker was removed and solid bus connections were made from the utility to the switchboard. Another fault caused the 10-circuit switchboard to be destroyed requiring complete replacement. Is bus differential relay protection for the new switchboard recommended and approximately how much will it cost? What are the types of bus differential protection available, how do they compare in price and what are the relative merits of each?**

Chemical Engineering Committee News

Professor John Lewis, former head of the Department of Paper Technology, Lowell Institute of Technology, now has been appointed vice-chairman of the Chemical Engineering Committee. A. W. Plummer is chairman and R. F. Clemens is secretary.

A subcommittee on Chemical Engineering Problems is designated as Project 780, headed by Lyle C. Jenness. This committee is assembling a collection of chemical engineering problems with solution to encourage the use of problems, discussion, and examination on pulp and paper technology in current chemical engineering curricular. Obviously, this work will be found useful in many other areas. As of mid-October 20 problems with solutions have been received. It is expected that there will be a substantial increase in further problems submitted by the Committee members and others in the immediate period ahead. This project promises to be extremely worth while.

At the joint APPA-TAPPI Research Conference in Chicago last October, Dr. Jenness described the work of this Subcommittee on Chemical Engineering Problems and approval was expressed by the educators present. Problems will be solicited from this group and also from industry.

Members of this subcommittee, in addition to Dr. Jenness, are:

J. E. Vivian	G. Rowlandson
W. Ingmanson	W. K. Neill
S. M. Neuville	J. L. McCarthy

The Chemical Engineering Committee functions with the following other active subcommittees:

Data Sheet Subcommittee. This committee initiates new data sheets and reviews and revises old ones to supply members of TAPPI and the industry with pertinent data in convenient form on processes and products. A. J. Chase is chairman.

Education Subcommittee. This committee has conducted a survey of the United States pulp and paper industry to measure the number of trained chemical engineers, regardless of position, now employed in the industry. This committee expects to repeat and refine the survey in the near future and will then embark on other appropriate objectives. A. W. Plummer is chairman.

Systems Engineering and Operations Research Subcommittee. This committee was appointed to encourage the application of systems engineering and operations research in the pulp and paper industry. Very successful technical sessions were sponsored by this subcommittee at our New York and Pittsburgh meetings in 1959. E. F. Thode is chairman.

Liaison Subcommittee. This is a new subcommittee formed to maintain contact and promote joint technical sessions with other TAPPI Committees who use chemical engineering principles and with other technical societies. E. C. Bowen is chairman.

Steering Subcommittee, headed by Mr. Plummer, has to do with committee policy and long range planning.

The scope and objective of the Chemical Engineering Committee is expressed as follows:

"The scope of the Chemical Engineering Committee is the study of the chemical engineering unit operations such as: flow of fluids, heat transfer, gas absorption, filtration, drying, humidification, etc., as applied to process development and design of equipment for the production of pulp and paper. The committee attempts to distribute such information through the publication of technical papers and data sheets. The committee also has the objective of evaluating the place of chemical engineers in the pulp and paper inustry and encouraging the practice of chemical engineering as related to the production of pulp and paper.

"The Chemical Engineering Committee concerns itself with all aspects of chemical engineering as applied to the pulp and paper industry. This interest ranges from educational curriculum for chemical engineers to achievement of management positions by chemical engineers in the industry. In between lies a large area which can be summarized as the systematic and integrated application of unit operations concepts, or as described more recently, the transport processes of mass, heat and momentum transfer."

R. F. Clemens, *Secretary*

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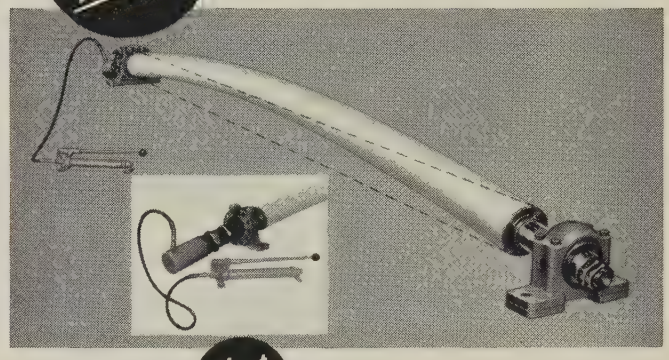

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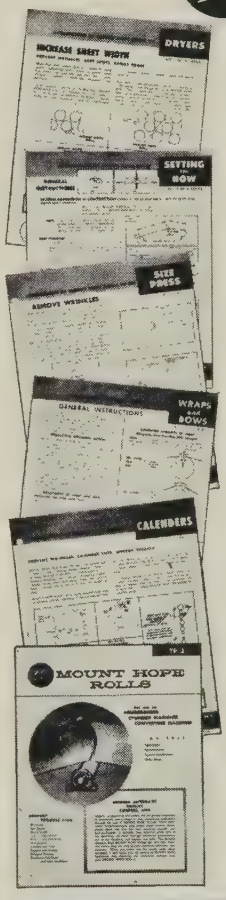

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Modulus of Rupture of Petroleum Waxes*

New Suggested Method T 655 sm

(THIS METHOD IS UNDER THE JURISDICTION OF THE JOINT TAPPI-ASTM WAX TESTING COMMITTEE)

This test describes a method of determining the modulus of rupture of a petroleum wax by applying a breaking load to a cast specimen and using the simple beam formula for elastic rigid bodies. It is not applicable to waxes which have more than 1/8-in. deflection under the test conditions used.

The modulus of rupture, is expressed as the maximum stress in pounds per square inch generated when breaking a specimen of a specified size with the apparatus described in this method. Because wax is not elastic and rigid up to the point of fracture, this calculated value is greatly in excess of the actual. However, it provides a useful basis of comparison.

In this method the specimen is cast over hot water and allowed to cool slowly in a room at 73 ± 2°F. Small slabs of stated dimensions are placed on two supports and fractured by adding a load under prescribed conditions. The modulus of rupture is calculated from the data.

APPARATUS

1. *Modulus of Rupture Apparatus,* comprising a pair of 0.25-in. diam., parallel cylindrical supports to hold a beam of the wax horizontally on a 2.0-in. span. To apply the load, a lightweight bucket is suspended by a stirrup from a 0.25-in. diam. breaking bar placed across the specimen at the center of the span. Arrangements are made to add water to the bucket at the rate of 18 oz. (530 ± 10 ml.) per min. until the specimen breaks, at which time the flow of water to the bucket is immediately diverted.

2. *Casting pans,* of seamless metal with internal dimensions of 8 1/8 by 4 3/4 by 3 1/4 in. deep.

3. *Covers for pans;* 9 by 6-in. glass.

4. *Hood* of metal or plastic to fit over a number of the casting pans to protect them from draughts.

5. *Circular Saw* with table and guides for accurately cutting 1/2-in. wide wax specimen strips.

6. *Thickness Gage* or dial micrometer to measure the thickness of the specimen up to 0.2 in. to the nearest 0.001 in.

7. *Beakers;* 150 to 250 ml., metal or glass, for the wax samples.

8. *Oven* to heat the beakers and wax to 20 ± 5°F. above their melting points.

TEST SPECIMEN

Into a clean beaker, weigh about 85 g. of a representative sample of the wax so as to provide a slab in the casting pan 0.150 ± 0.010 in. thick. Heat each sample in the oven to 20°F. above its melting point. Boil about 1 l. of distilled or freshly filtered tap water for each sample to be tested. Pour the boiling water into a clean casting pan, then slowly pour a molten wax sample onto a spatula partly immersed in the water in the pan so as to prevent splattering and to avoid entrainment of air. Place a cover glass over each pan and then cover all the pans with the hood to avoid any drafts. Allow the samples to cool for at least 8 hr. at 73 ± 2°F.

After the sample has cooled, cut around the outer edge of the wax with a thin bladed spatula and remove the sample from the casting pan. Place the sample on a glass plate, score with a sharp knife to give a central section of the slab approximately 3 by 8 in. Break off the side scored portions along the long axis of the slab. Place the prepared slab, water side down, on the saw carriage with the long edge against the cross slide bar and the short edge against the gage block. Steadily push the carriage the entire length of the saw table while applying sufficient pressure to the wax slab to prevent it from rising off the table. Saw the entire slab into 1/2-in. strips and discard the first strip cut and the last half-inch or wider piece. Without touching the strips on their flat surfaces, gently remove any adhering wax chips and place the strips on a glass plate. Do not handle them any more than necessary. Allow the strips to stand at least 1 hour at 73 ± 2°F. before testing. The above procedure should give about 14 wax strips measuring 0.500 ± 0.010 by 0.150 ± 0.010 by 3 in. Discard any strips with obvious defects and select the 10 specimen strips closest to the center of the casting, for testing.

PROCEDURE

Adjust the flow of water into the supply tank so that a small amount of overflow occurs while the specified flow of 18 oz. per min. (530 ± 10 ml. per min.) flows from the orifice. Adjust the water stop so that water from the orifices flows into the sump. Mount a specimen strip on the apparatus by lifting the breaking bar assembly and sliding the test strip over the two span

* This method is suggested by the Standards Committee as being the most suitable to date. It is *not,* however, a TAPPI Standard. Criticisms are invited and should be sent to the Secretary, TAPPI, 360 Lexington Ave., New York 17, N. Y.

supports under the centrally located breaking bar, taking care to see that the strip is centered on the span. Slowly allow the breaking bar to rest on the test strip. Immediately after putting the test strip on the apparatus, move the water stop so that the water from the orifice is directed into the catch bucket attached to the breaking bar. After the specimen fractures, with a graduated cylinder, measure the volume of water in the bucket to the nearest 10 ml. and record this volume (i.e., weight) plus the fixed weight of the bucket and breaking bar assembly (usually about 60 g.), as the breaking load of the test strip. Remove both halves of the test strip and, with the thickness gage, measure their width and thickness at the point of fracture.

Repeat the procedure, breaking five specimens with their air-cooled side up and five specimens with this side down, alternating from one to the other to avoid minor variations in handling.

Calculate the modulus of rupture (M.R.) in pounds per square inch for each test strip from the equation:

$$\text{M.R.} = \frac{3PL}{2BT^2}$$

where

P = total weight required to break specimen, in pounds
L = distance between supports, in inches
T = thickness of specimen, in inches
B = width of specimen, in inches

When L = 2 in. and the breaking load is W grams, the formula reduces to:

$$\text{M.R.} = \frac{0.0066\ W}{BT^2} \text{ p.s.i.}$$

Calculate the over-all average for the ten strips. A typical accumulation of data is shown in Table I.

REPORT

Report the average modulus of rupture in pounds per square inch, to three significant figures.

PRECISION

The following criteria should be used for judging the acceptability of the mean of results of tests on ten strips:

1. Repeatability—the means of duplicate sets of results by the same operator, should be considered suspect if they differ by more than 2.5%.
2. Reproducibility—the means of sets of results in different laboratories, should be considered suspect if they differ by more than 8.5%.

Table I. Typical Data for Modulus of Rupture Test of Wax

	Milliliters water and total breaking weight, g.	*Thickness, in.*	*Width, in.*	*M.R., p.s.i.*
Air side up	700	0.149	0.493	458
	700	0.150	0.499	477
	800	0.153	0.500	484
	780	0.151	0.502	484
	710	0.149	0.503	455
	Av. 738 + 60 = 798	0.150	0.500	472
Air side down	750	0.150	0.506	471
	750	0.151	0.499	473
	790	0.150	0.500	496
	720	0.150	0.503	454
	700	0.148	0.500	457
	Av. 742 + 60 = 802	0.150	0.501	470
	Grand average M.R. = 471 p.s.i.			

Needle Penetration of Petroleum Waxes*

Revision of T 639 sm-58

(THIS SUGGESTED METHOD IS UNDER THE JURISDICTION OF THE JOINT TAPPI-ASTM WAX TESTING COMMITTEE)

This method covers a procedure for the empirical estimation of the consistency of waxes derived from petroleum by measurement of the extent of penetration of a standard needle. Penetration of a petroleum wax is the depth, in tenths of a millimeter, to which a standard needle penetrates into the wax under defined conditions: the sample is melted, heated to 30°F. above its melting point, and then cooled to 77°F. The penetration is measured with a penetrometer by means of which a standard needle is applied to the sample for 5 sec. under a load of 100 g. The method is applicable to waxes having a penetration of not greater than 150 units.

APPARATUS

1. *Penetrometer*, having means for applying the tip of the standard needle to the surface of the specimen and means for measuring the extent of penetration at the conclusion of the test, such as an indicator gage with a suitable attachment.

The penetrometer is constructed in such a manner that an accurate placement of the tip of the needle adjoining the level surface of the specimen may be made. Figure 1 represents a composite drawing illustrating the two available types of instrument, that with an adjustable table and that with an adjustable needle assembly; the use of either type instrument is permissible. When released, the loaded needle descends without appreciable friction. Means are provided, such as leveling screws and a spirit level, to maintain the needle and shaft in a true vertical position.

2. *Timing Device.* An automatic timing release mechanism for the needle attached to the penetrometer. Alternatively, a stopwatch graduated in 0.1-sec. intervals.

3. *Needle and Plunger.* The needle shall be of highly polished, hardened stainless steel, approximately 83 mm. long and 4.3 mm. diam. with a blunted point 0.15 ± 0.01 mm. diam. and conforming to the

* This method is suggested by the Standards Committee as being the most suitable to date. It is *not*, however, a TAPPI Standard. Criticisms are invited and should be sent to the Secretary, TAPPI, 360 Lexington Ave., New York 17, N. Y.

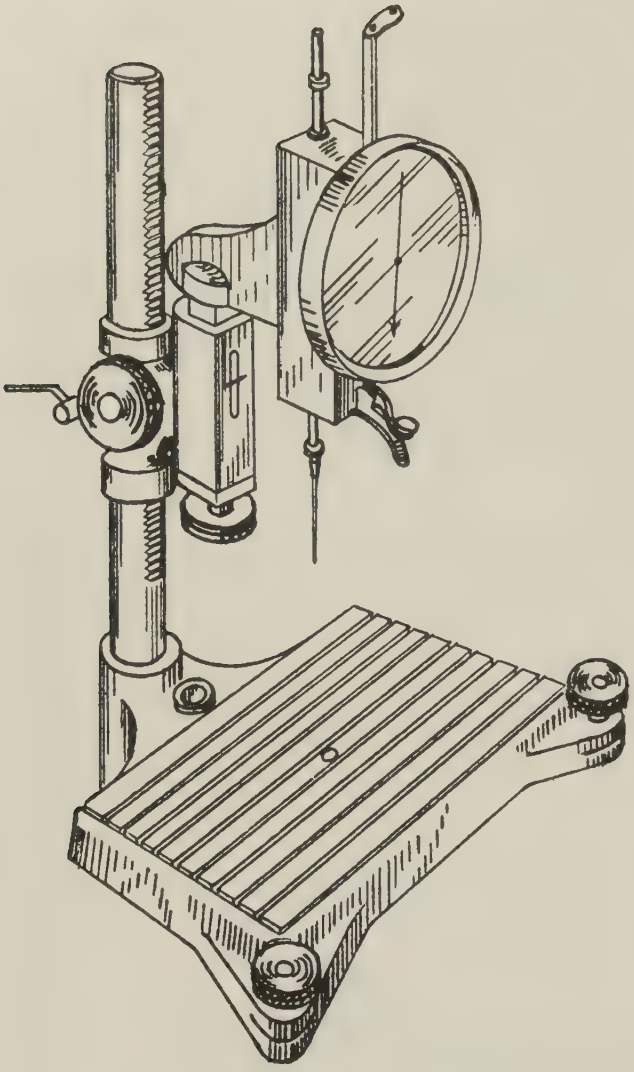

Fig. 1. Composite of two available type of penetrometer instruments

dimensions shown in Fig. 2. The total weight of the plunger shall be 47.5 ± 0.05 g. and that of the needle, 2.5 ± 0.05 g. A removable weight of 50 ± 0.05 g. shall be mounted on the plunger, so that a total weight of 100 ± 0.15 g. may be applied to the needle point.

Note: The National Bureau of Standards will measure and certify the accuracy of penetration needles in accordance with these permissible variations.

4. *Test Specimen Mold.* A brass cylinder open at both ends, 1 in. i.d., $1^1/_4$ in. high with $^1/_8$-in. walls. To prevent slippage of very hard wax, a few screw threads or grooves are cut into the center part of the inside wall of the cylinder. A base and closure for the bottom of the cylinder comprises a small plate of brass ($2^1/_2 \times 1^1/_2 \times {}^1/_4$ in.).

5. *Test Room* or *Cabinet* capable of being maintained at 75 ± 4°F.

6. *Water Bath* of at least 10-l. capacity capable of being maintained at the test temperature ±0.2°F. (See note.) The water bath is made of glass or has a window to permit a horizontal view of the specimen. It is so constructed that it is possible to immerse the test specimen in the bath to a depth of not less than 4 in. and to support it on a perforated conditioning shelf not less than 2 in. from the bottom of the bath. The bath also is equipped with a rigid perforated test shelf

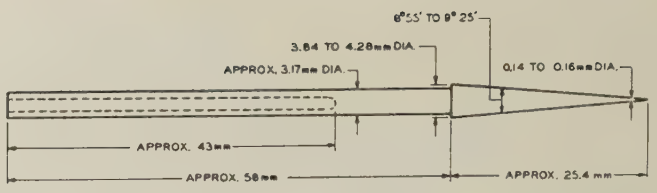

Fig. 2. Dimensions of standard needle. Shaft drilled out and length adjusted to give final weight of 2.5 ± 0.05 grams

about 2 in. below the water level to support the specimen during penetration by the needle.

Note: The test may be performed at any temperature in the range 75–130°F. Temperatures of 77°, 90°, 100°, 110°, or 120°F. are most usual.

7. *Thermometer* for use in water bath. A precision thermometer, total immersion, having a range of 77° to 131°F. and conforming to the requirements for thermometer 64F as prescribed in Standard Specifications for ASTM Thermometers (ASTM Designation E 1.).

Note: The main requirements are: 0.2°F. subdivisions; scale error less than 0.2°F.; length 374–384 mm.; stem diam., 7–8 mm.; bulb length 25–35 mm.; bottom of bulb to graduation line at 77°F., 115–135 mm.; bottom of bulb to graduation line at 131°F., 324–344 mm.

TEST SPECIMEN

Heat the wax sample to approximately 30°F. above its melting point (as determined by TAPPI Standard T 630 m or T 634 m), using care to prevent local overheating. Stir until the sample is homogeneous and free from air bubbles. In the test room or cabinet maintained at 75 ± 4°F., mount the brass mold support plate on two corks (no. 16 or 18 recommended) and wet the surface of the plate with a mixture of equal volumes of glycerin and water. Place the test specimen mold on the plate and then pour the melted wax into it in such a way that a convex meniscus is formed. Allow the container and contents to cool in the room at 75 ± 4°F. for 1 hr. Shave any excess wax from the top of the mold and remove the brass plate.

Note: Very hard waxes occasionally will shrink away from the walls of the test specimen container; in such cases, it is permissible to wedge the specimen in the container.

PROCEDURE

Reverse the penetrometer base to the rear, if this is possible, then place the penetrometer head over the edge of the water bath and above the perforated test shelf used for supporting the specimen. A weight may be placed on the reversed base of the penetrometer to counter-balance the head. Level the penetrometer and the perforated shelf in the water bath.

Note: Alternatively, either the penetrometer base may be placed in the water bath; or a small bath may be placed on the penetrometer stand provided the test temperature ±0.2°F. and the required water circulation above and below the sample are maintained. If this alternative is used, with the thermometer specified, measure the temperature of the small bath immediately prior to testing each specimen. Apply an emergent stem correction when the correction equals or exceeds 0.1°F. One of these alternatives will be required if the penetrometer is the adjustable table type.

Place the specimen mold on the perforated test shelf with the smooth wax surface that had contacted the brass plate, at the top. Make certain that the container or test shelf is firm and cannot rock during test-

ing. Adjust the water level so that it is 1 in. above the top surface of the specimen.

Place a 50-g. weight on the top of the penetrometer needle, making a total load of 100 ± 0.15 g. for the needle and all attachments. Observe that the release mechanism does not drag on the shaft and that the indicator on the scale is in the "zero" position. Adjust either the indicator assembly or the table, depending upon the type of instrument, until the tip of the needle nearly touches the surface of the specimen. Securely lock the movable assembly in this position.

By means of the slow-motion adjustment, bring the needle tip to just touch the surface of the specimen, watching the reflection of the needle tip as an aid to accurate setting. After 5 min., release the needle shaft so that it moves freely downwards to penetrate the wax under a load of 100 g., hold it free for exactly 5 sec., then lock it, timing this interval automatically or with a stopwatch graduated to 0.1 sec. (See note.) Then gently depress the indicator shaft until it is stopped by the needle shaft and read the penetration made during the 5-sec. interval from the indicator scale.

Note: If an automatic timing release mechanism is not used, the timing can be done conveniently by starting the watch before the beginning of the test, releasing the needle shaft as the second hand crosses a unit graduation of the watch and engaging the shaft of the needle when the watch indicates exactly 5 sec. later.

Make four tests at points about equally spaced but not less than $^1/_2$ in. apart on a circumference at least $^1/_8$ in. from the side of the mold. Before each test, carefully wipe the needle toward its point with a clean, dry cloth to remove all adhering wax and position the needle as described above.

REPORT

Record the average of four penetrations into the prepared specimen to the nearest penetration unit (1 unit = 0.1 mm.). Report the actual test temperature used.

PRECISION

Duplicate test values should be considered suspect if they differ by more than the following, the percentages being based on the smaller of the two values:

	0–30	Above 30
Repeatability	2	8%
Reproducibility	4	15%

ADDITIONAL INFORMATION

1. In this revision the scope has been widened to waxes having a penetration up to 150 units. The water bath alone is now specified for the test.
2. Related method: ASTM D 1321–59 T.

Solubility of Pulp in Sodium Hydroxide at 20°C.*

Proposed Revision of T 235-58

(THIS STANDARD IS UNDER THE JURISDICTION OF THE CHEMICAL METHODS COMMITTEE)

This is a general cold-alkali solubility test for cellulose or pulp arranged for use with various and constant concentrations of caustic soda. The concentration of sodium hydroxide solution most frequently used is 18%. Concentrations of 5, 10, 21.5, and 50% are also employed depending on the use requirements of the pulp. For example, results with 21.5% have been shown to correlate in general with the yield of rayon in the viscose process.

This method, avoids the sequential dilution step for the chosen concentration of sodium hydroxide as in TAPPI Standard T 203 m and thus gives results which are not strictly comparable with it. This standard is considered to be more meaningful than T 203 m by the responsible committees in TAPPI, ASTM, and ACS. Also, here the soluble fraction of the pulp is determined rather than the insoluble residual fraction as in T 203 m. This avoids the acidfication and washing of a residue with indeterminate effects.

The term "alpha-" cellulose should not be applied to any test value obtained with this procedure since it is defined only by the method of its determination specified in T 203 m, which, in a modified form, is being retained as a TAPPI Standard for alpha-cellulose, mainly for historical reasons.

This procedure is recommended for general pulp evaluation and for purchase specifications.

APPARATUS

1. *Stirring Equipment*, generally as shown in Fig. 1. The exact dimensions are not critical. The stirrer and shell assembly is alkali-resistant; e.g., of stainless steel. A satisfactory motor is a $^1/_{50}$-hp. variable speed motor adjusted to go at about 1500 r.p.m. The pitch of the blades, or speed of the motor, is adjusted so that no air is introduced into the pulp suspension during stirring.
2. *Constant Temperature Bath*, capable of maintaining a temperature of 20 ± 0.2°C.; large size.
3. *Filtering Crucible*, 30 ml., alkali resistant, with fritted disk of coarse porosity (nominal maximum pore size, 40 to 60 μ).
4. *Suction Flask*, for the crucible.
5. *Other Equipment*, 10 and 100-ml. pipets, 250-ml. beaker with watch glass cover, 100-ml. volumetric flask, 250 and 1000-ml. Erlenmeyer flasks, with stopper for the 250-ml. flask, glass stirring rod.

* This revision has been proposed by the Chemical Methods Committee. Criticisms are invited and should be sent to the Secretary, TAPPI, 360 Lexington Ave., New York 17, New York.

REAGENTS

A. *Sodium Hydroxide Solution:* one of the concentrations below having an amount of sodium carbonate present less than 1 g.p.l.

To prepare the 18% solution, dissolve a quantity of solid sodium hydroxide in an equal weight of distilled water, cover and allow the suspended carbonate to settle, which may take several days, decant or syphon off the clear supernatant liquid, and dilute with carbon dioxide-free distilled water until the specific gravity at 20°/4°C. is 1.1972 ± 0.0012 (the correction per degree Centigrade is 0.00051). Check the final dilution by a titration with standard acid. The Na_2CO_3 content of the dilute solution should not exceed 1 g.p.l.

1. NaOH, 5.0 ± 0.1 g. NaOH per 100 g. solution, sp. gr. is 1.0538, 1.32 *N* at 20°/4°C.
2. NaOH, 10.0 ± 0.1 g. NaOH per 100 g. solution, sp. gr. is 1.1089, 2.77 *N* at 20°/4°C.
3. NaOH, 18.0 ± 0.1 g. NaOH per 100 g. solution, sp. gr. is 1.1972, 5.39 *N* at 20°/4°C.
4. NaOH, 21.5 ± 0.1 g. NaOH per 100 g. solution, sp. gr. is 1.2356, 6.64 *N* at 20°/4°C.
5. NaOH, 50.0 ± 0.1 g. NaOH per 100 g. solution, sp. gr. is 1.5253, 19.07 *N* at 20°/4°C.

B. *Potassium Dichromate*, 0.4 *N* 20 g. $K_2Cr_2O_7$ with 150 ml. of conc. H_2SO_4 per liter.

C. *Sulfuric Acid* conc. (94–95% H_2SO_4, sp. gr. 1.84), reagent grade.

D. *Sodium Thiosulfate*, 0.1 *N*. $Na_2S_2O_3$, accurately standardized.

E. *Potassium Iodide*, solid KI, reagent grade.

F. *Starch Solution*, 0.5% (or Thyodene powder).

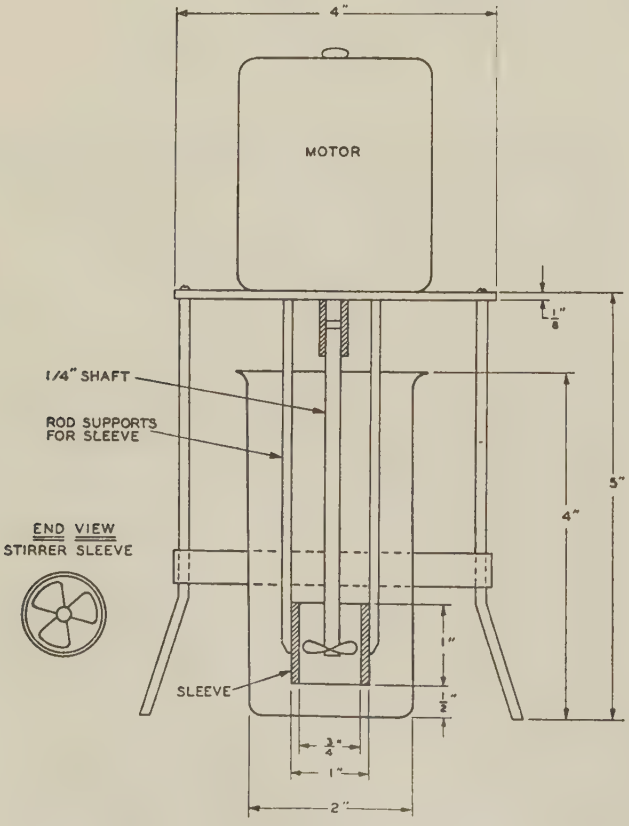

Fig. 1. Stirring equipment

TEST SPECIMEN

Obtain a sample of pulp which is representative of the entire lot being tested weighing at least 5 g. for duplicate tests. If in sheet form split, then tear into pieces approximately 5 to 10 mm. across. Do not cut with a pair of scissors nor use a grinder. If in slush form, dewater by suction, press between blotters to dry as much as possible and pull apart into small pieces. Spread the torn pieces on a tray open to the laboratory air for at least 24 hr., to attain uniform moisture content. At about the same time take composite specimens for the moisture and alkali solubility determinations.

PROCEDURE

With a pipet, add 100 ml. of the chosen NaOH solution to a 250-ml. beaker. Adjust the temperature, preferably by placing it in the constant temperature bath, to 20 ± 0.2°C.

Note: The solubility in 18% NaOH is not affected by variations of a few degrees in temperature. In this case the temperature may be kept at 20 ± 2°C. The solubility in weaker alkali (for example 10% NaOH) is much more dependent on temperature. At this lower concentration, the temperature of the mixture should be maintained at 20 ± 0.2°C., even during subsequent disintegration.

Weigh, to the nearest 5 mg. or less the equivalent of 1.5 ± 0.05 g. of moisture-free pulp. At about the same time, weigh another portion and determine its exact moisture content in accordance with TAPPI Standard T 208 m or T 412 m. Put the specimen into the alkali and allow it to swell for 2 min. Stir in the equipment for 3 min. without aeration. This is sufficient time to defiber most pulps completely, which is essential. An increase in the stirring time does not significantly affect the solubility; too low a value will be obtained if defibering is not complete. Keep stirring therefore, until the sample is completely defibered. Lift the stirrer from the beaker. Carefully clean the stirring apparatus and walls of the beaker with a glass rod so that all pulp fibers will be retained in the caustic. Cover the beaker with a watch glass and allow the beaker with the sample to remain at 20 ± 0.2°C. for a period of 60 min. from the time the specimen was added to the caustic.

At the end of 60 min., less the few minutes necessary to collect the filtrate, stir the slurry with the glass rod, and filter with suction through the fritted glass crucible. During filtration, keep the cellulose mat on the filter covered with solution and be careful not to pull any air through it. Reject the first 10 to 20 ml. and, in a clear dry bottle or flask, collect the next 40 to 50 ml. of the filtrate for testing. If any suspended fibers are noticed in the filtrate, pass the filtrate through the cellulose mat again to be clarified. Keep the filtrate in a stoppered Erlenmeyer flask and allow it to come to room temperature.

Note: During the early stages of the treatment the amount of material dissolved increases with the time of alkali leaching but after a certain time usually very little more is dissolved. For dissolving pulps, 1 hr. is usually sufficient, but for some paper grade pulps, such as hardwood neutral sulfate and some semichemical and sulfate pulps, a longer time may be required. This should be checked by experiment. If a longer period than 1 hr. is used, the results will not be in accordance with this method and a special note should be appended to the results.

DETERMINATION OF DISSOLVED CELLULOSE

Determine the cellulose in the filtrate by oxidation with the dichromate solution.

With a pipet, transfer 10 ml. of the filtrate to a 250-ml. Erlenmeyer flask. Add 10 ml. of 0.4 N $K_2Cr_2O_7$ and then carefully add 30 ml. of conc. H_2SO_4. If the sulfuric acid is of lower concentration than 94%, the temperature will not reach the required 125 to 130°C. during the oxidation. Swirl to mix and apply heat to maintain a solution temperature of 127 ± 2°C. for a 10-min. period to complete the oxidization. Use of a reflux system for the flask is desirable.

Cool the flask to room temperature and quantitatively transfer the solution to a 1-l. Erlenmeyer flask, using 500 ml. of distilled water. Add approximately 2 g. of solid KI, swirl to dissolve and mix, then allow to stand for 5 min. Titrate with the 0.1 N $Na_2S_2O_3$ solution, adding the starch indicator near the end point when the yellow color of the iodine has nearly disappeared. The end point occurs when the color of the solution changes from deep blue to light green. Make a blank determination, substituting a 10-ml. portion of the 18% or other NaOH solution for the filtrate and using approximately the same temperature and time to complete the titration.

Note: A 10-ml. aliquot of the filtrate is sufficient for most dissolving pulps. For pulps having a very high solubility (greater than 16%) decrease the volume of the filtrate to 5 ml. and the H_2SO_4 to 25 ml. For highly insoluble pulps use a 20-ml. portion of filtrate and 45 ml. of H_2SO_4.

Calculate the percentage of the pulp soluble in alkali as:

$$\frac{(V_2 - V_1) \times N \times 6.85 \times 10}{W \times S}$$

where

N = exact normality of the $Na_2S_2O_3$
W = weight of the moisture-free pulp in grams
V_1 = $Na_2S_2O_3$ consumed in the titration of the specimen in milliliters
V_2 = $N_2S_2O_3$ consumed by blank in milliliters
S = milliliters of alkaline filtrate used in the oxidation
6.85 = milligrams of cellulose equivalent to 1 milliequivalent of $K_2Cr_2O_7$.

Note 1: Theoretically 1 (me.) of $K_2Cr_2O_7$ corresponds to 6.75 mg. of cellulose of polyoses, but under less ideal conditions of the oxidation described above, 1 milliequivalent corresponds to approximately 6.85 mg. of cellulose.

Note 2: On each occasion the equivalence factor for the conditions and solutions employed may be determined as follows:

Without heating, dissolve 0.2 ± 0.001 g. (moisture-free) of high-quality, bleached-cotton linters or ashless filter paper in 40 ml. of 72% H_2SO_4, and in a 100-ml. volumetric flask, dilute to the mark with more 72% acid. Immediately thereafter, pipet (see *note*) duplicate 10-ml. aliquots of the cellulose solution into a pair of 500-ml. Erlenmeyer flasks, add 40 ml. 0.5 N NaOH to each, and another 40-ml. portion of the NaOH to another flask as a blank. Oxidize and titrate the blank and each flask containing the 20 mg. of cellulose as described above. Suppose the results are V_3 and V_4 ml. respectively; then the equivalence factor (mg. of cellulose per ml. of N solution) or mg. of cellulose per 10 ml. of the 0.1 N $Na_2S_2O_3$ as used—the portion replaced by the cellulose having been oxidized—is $200/(V_3 - V_4)$.

Note: Take care that the 10-l. pipet used to deliver the cellulose aliquot is calibrated for the delivery of that solution, since it is more viscous than water. (Using the same 10-ml. pipet as was used for the specimen will minimize the possible error.)

Note 3: Alternatively, in place of the KI and $Na_2S_2O_3$ titration, after cooling the oxidized solution to room temperature, add 50 ml. of water to the specimen and to the blank. Cool again to room temperature, add 2 to 4 drops of ferrion indicator* and titrate with a freshly standardized 0.1 N solution of ferrous ammonium sulfate (40.5 g. $FeSO_4(NH_4)_2SO_46H_2O$ + 10 ml. conc. H_2SO_4 per liter) to a purple color. In the calculation above, V_1 and V_2 will represent the volume of ferrous ammonium sulfate used for the specimen and the blank, respectively. An electrometric titrimeter is preferable for this titration.

REPORT

Report to one decimal place the percentage of the moisture-free pulp which was dissolved by the alkali, and also the strength of the alkali solution used.

The strength of the NaOH solution may be designated by a numerical suffix, e.g., the solubility in 18% NaOH as x% S18.

PRECISION

The standard deviation for all NaOH concentrations is approximately 0.1.

ADDITIONAL INFORMATION

1. This solubility method may be applied to one particular pulp using several concentrations of alkali (5, 10, 18, 21.5%, etc.). The resulting relative solubilities may help to determine the suitability of the pulp for various industrial processes.

2. Reporting the difference between 100 and the percentage of alkali-soluble material in accordance with this, or any method other than TAPPI Standard T 203 m, as "alpha-cellulose" or "modified alpha-cellulose" or "new alpha-cellulose," is misleading and should be strongly discouraged.

3. The principal changes in this revision are: (a) heat is applied to oxidize the cellulose with dichromate and (b) a procedure is given for determining the cellulose equivalence factor in the volumetric determination, if desired.

4. Similar methods are: ASTM D 1696–59 T, Swedish APPE Method CCA 8–55, and German VZ u PC&I Mrkblatt IV/29.

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* Ferroin Indicator—1.5 g. *o*-phenanthroline monohydrate (or 1.6 g. of the hydrochloride) plus 0.7 g. $FeSO_4$, dissolved in water and diluted to 100 ml.

Eleventh

Testing Conference

of

The Technical Association

of the

Pulp and Paper Industry,

Pantlind Hotel

Grand Rapids, Mich.

Sept. 22–29, 1960

Alpha-, Beta-, and Gamma-Cellulose in Pulp*

Proposed Revision of T 203 m-58

(THIS STANDARD IS UNDER THE JURISDICTION OF THE CHEMICAL METHODS COMMITTEE)

CELLUOSE pulp consists of two, arbitrarily defined, main carbohydrate fractions: the alpha fraction of high molecular weight, which is insoluble in sodium hydroxide of mercerizing concentration (17.5%), and the hemicellulose fraction, which is contained in the short-chain material that dissolves. The hemicellulose fraction can be divided further into beta- and gamma-cellulose.

The division of the pulp into these three fractions is by a highly empirical procedure originally devised by Cross and Bevan in 1897, and which has been used since then to define alpha-, beta-, and gamma-cellulose.

The pulp is treated with a definite amount of 17.5% NaOH solution for 45 min. The concentration of the sodium hydroxide is then reduced to 8.3% and the mixture treated for another 30 min. The alpha-cellulose is separated by filtration through a filter crucible, washed, dried, and weighed.

The total beta-plus gamma fraction is determined volumetrically in an aliquot of the alkaline filtrate after oxidation with dichromate. Another aliquot of the alkaline filtrate is acidified, filtered, and the gamma-fraction (that which remains in the filtrate) is similarly determined.

Note 1: This standard for determining the alpha-cellulose, with some revisions to secure better reproducibility, but which unfortunately, do change the results, is being preserved mainly for historical reasons. (See "Additional Information.")

TAPPI Standard T 235 m, Solubility of Pulp in Sodium Hydroxide, is superior to this method for characterizing pulps and should be preferably used for purchase specifications and for measuring the suitability of pulps for various dissolving processes.

Note 2: The procedure is best suited to bleached pulps. Some unbleached pulps may prove so difficult to filter that they may require a prior chlorite or holocellulose treatment.

Note 3: For the determination of alpha-cellulose in paper, see TAPPI Standard T 429 m.

APPARATUS

1. *Water Bath*, 20.0 ± 0.2°C., large size.
2. *Filtering Crucible*, low form, 30 ml., alkali resistant with fritted disk of coarse porosity (nominal maximum pore size 40 to 60 μ).
3. *Suction Flasks*, for crucible; two.
4. *Weighing Bottle*, glass stoppered, large enough to hold the filtering crucible.
5. *Glass Stirring Rod*, about 7 in. long, with one end flattened to a disk about 1 cm. diam.
6. *Other Equipment:* 100-ml. graduate, 250-ml. beaker with watch glass cover, 100 and 500-ml. volumetric flasks, 250-ml., 500-ml., and 1-l. Erlenmeyer flasks, 10-ml. and 50-ml. pipets, 250-ml. glass-stoppered graduated cylinder and litmus paper.

REAGENTS

A. *Sodium Hydroxide Solution*, 17.5 ± 0.1 g. NaOH per 100 g. of solution. Dissolve a quantity of solid sodium hydroxide in an equal weight of distilled water, cover and allow the suspended carbonate to settle, which may take several days. Decant or syphon off the clear supernatant liquid and dilute with CO_2-free distilled water until the specific gravity at 20°/4° is 1.192 ± 0.001 (correction per °C. = 0.00051.) Check the final dilution by titration with standard acid. The Na_2CO_3 content of the diluted solution should not exceed 1 g.p.l.

B. *Sodium Hydroxide Solution*, 8.3 g. NaOH per 100 g. of solution. Dilute another portion of 50% NaOH with CO_2-free distilled water to a sp. gr. of 1.090 ± 0.001 at 20°/4°.

C. *Acetic Acid*, 2 *N*.

D. *Sulfuric Acid*, conc. (94–95% H_2SO_4 sp. gr. 1.84), reagent grade. Also 6 *N* H_2SO_4.

E. *Potassium Dichromate*, 0.4 *N* 20 g. $K_2Cr_2O_7$, with 150 ml. conc. H_2SO_4 per liter.

F. *Sodium Thiosulfate*, 0.1 *N* $Na_2S_2O_3$, accurately standardized.

G. *Potassium Iodide*, Solid KI, reagent grade.

H. *Starch Solution*, 0.5% (or Thyodene powder).

TEST SPECIMEN

Obtain a sample of pulp which is representative of the entire lot being tested, weighing at least 10 g. If in sheet form, split, then tear it into pieces approximately 5 to 10 mm. across. Do not cut with a pair of scissors nor use a grinder. Spread the torn pieces on a tray open to the laboratory air for at least 24 hr. to attain uniform moisture content. At about the same time take composite specimens for the moisture and alpha-cellulose determinations.

PROCEDURE

A. Alpha-Cellulose

During the procedure, keep the NaOH solutions, distilled water, and acetic acid at 20.0 ± 0.2°C.; this is conveniently done by placing them in flasks held in the water bath. The water used for the final rinse of the alpha-cellulose residue, however, need not be at exactly 20°C. Heat the fritted glass crucible and weighing bottle in an oven at 105 ± 3°C. to constant weight (±0.5 mg.), place the crucible in its bottle, and stopper tightly. Cool in a desiccator for an hour or more. Loosen the cover of the bottle momentarily to equalize the pressure and weight to the nearest milligram.

Weigh to the nearest 5 mg. or less, the equivalent of 3.0 g. of moisture-free pulp. At about the same time, weigh another portion and determine its exact moisture content in accordance with TAPPI Standard T 208 m or T 421 m. Transfer the specimen for the

* Minor changes may be made in this method before publication in loose-leaf form. Suggestions are invited.

alkali treatment to a 250-ml. beaker in the water bath. Accurately measure 75 ml. of the 17.5% NaOH solution into a graduate at 20°C.

Wet the pulp with 15 ml. of the NaOH solution and macerate gently with the flattened glass rod for 1 min., add 10 ml. more and mix for 45 sec., then 10 ml. more and mix for 15 sec.; so that at the end of 2 min., 35 ml. of the NaOH have been added to form a slurry free from lumps, with the minimum amount of maceration. Stir and allow the mixture to stand for another 3 min. Without removing the beaker from the bath, add an additional 10 ml. of the NaOH solution and mix with the flattened glass stirring rod for a total of 10 min. more, meanwhile adding the remaining 30 ml. of the NaOH solution in 10-ml. portions, after 2.5, 5, and 7.5 min.

At the end of the 10-min. period, without removing the stirring rod, cover the beaker with a watch glass and leave the mixture in the water bath for 30 min. more, a total of 45 min. after adding the first portion of sodium hydroxide. Then add 100 ml. of distilled water at 20°C.; quickly and thoroughly mix and leave the diluted mixture in the water bath for an additional period of 30 min., a total period of 75 min. in contact with sodium hydroxide.

Note: Contact with the resulting 8.3% NaOH, in which a small portion of the treated specimen is quite soluble, has been lengthened in order to avoid the uncertainty as to how much of this fraction is inadvertently dissolved after the dilution.

Pour the contents into the tared fritted crucible on a clean suction flask. If suspended fibers are noticed in the filtrate, pass it through the cellulose mat again to clarify it. Rinse the beaker and residue with 25 ml. of 8.3% NaOH solution at 20°C. and quantitatively transfer all the fibers to the crucible. During the filtration, always keep the cellulose pad covered with solution to prevent drawing air through the pulp pad. Wash the filtered residue, using five 50-ml. portions of distilled water at 20°C. Set aside the filtrate (which should be less than 500 ml.) for the determination of beta- and gamma-cellulose.

Note: It is assumed that the filtering procedure will occupy about 5 min. If the pulp is difficult to filter, taking over 5 min., decrease the 30-min. standing time for subsequent specimens of that pulp accordingly.

Place another suction flask in position and wash the residue in the crucible with an additional 400 ml. of distilled water, discarding the filtrate. Disconnect the suction tube, add 40 ml. of 2 *N* CH_3COOH at 20°C. and allow the residue to soak for 5 min. Reapply the suction and draw off the acetic acid. Wash the residue with water until it is free from acid, as indicated by litmus paper.

Wipe the bottom and sides of the crucible with a dry towel and place it in an oven at 105 ± 3°C. along with its weighing bottle. Dry to constant weight; then cool and weigh in its weighing bottle as before. Avoid prolonged heating because after it reaches a minimum, again in weight will occur.

Calculate the alpha-cellulose as a percentage, based on the moisture-free pulp.

Correction for Ash and Lignin. Correct results from those pulps with appreciable ash, and from unbleached pulps, for their ash and lignin contents according to T 222 m and T 211 m, respectively. Subtract these quantities from the weight of the alpha-cellulose to obtain the corrected value.

B. Beta and Gamma-Cellulose

Quantitatively transfer the alkaline filtrate from the suction flask to a 500-ml. volumetric flask, make up to the mark with distilled water, and mix.

Determine the cellulose dissolved in the alkali by oxidation with the dichromate solutions as follows:

With a pipet, transfer 50 ml. of the filtrate to a 500-ml. Erlenmyer flask. Add 10 ml. of 0.4 *N* $K_2Cr_2O_7$ and then carefully, 90 ml. of conc. H_2SO_4. If the H_2SO_4 is of lower concentration than 94%, the temperature will not reach the required 125 to 130°C. during the oxidation. Swirl to mix and apply heat to maintain a solution temperature of 127 ± 2°C. for a 10-min. period to complete the oxidation. Use of a reflux system for the flask is desirable.

Cool the flask to room temperature and quantitatively transfer the solution to a 1-liter Erlenmeyer flask, using 500 ml. of distilled water. Add approximately 2 g. of solid KI, swirl to dissolve, and allow it to stand for 5 min. Titrate with the 0.1 *N* $Na_2S_2O_3$ solution, adding the starch indicator near the end point when the yellow color of the iodine has nearly disappeared. The end point occurs when the color of the solution changes from deep blue to light green. Make a blank titration substituting a 50-ml. portion of the 0.5 *N* NaOH for the filtrate, using approximately the same temperature and time to complete the titration. Calculate the percentage of beta-plus gamma-cellulose as:

$$\frac{(V_2 - V_1) \times N \times 6.85}{W}$$

where

V_1 = $Na_2S_2O_3$ consumed in the titration of the filtrate in milliliters
V_2 = $Na_2S_2O_3$ consumed in the titration of the blank in milliliters
N = normality of the $Na_2S_2O_3$ solution
W = moisture-free weight of the pulp used in grams (3.0)
6.85 = milligrams of cellulose corresponding to 1 milliequivalent (me.) of $K_2Cr_2O_7$

Note 1: Theoretically 1 ml. of $K_2Cr_2O_7$ corresponds to 6.75 mg. of cellulose or polyoses, but under the less ideal conditions of the oxidation described above, 1 ml. corresponds to 6.85 mg.

The equivalence factor for the conditions and solutions employed for each occasion may be determined as follows:

Without heating, dissolve 0.2 ± 0.001 g. (moisture-free) of high-quality, bleached cotton linters or ashless filter paper in 40 ml. of 72% H_2SO_4, and in a 100-ml. volumetric flask, dilute to the mark with more 72% acid. Immediately thereafter, pipet (see *note*) duplicate 10-ml. aliquots of the cellulose solution into a pair of 500-ml. Erlenmeyer flasks, add 40 ml. 0.5 *N* NaOH to each, and another 40-ml. portion of the NaOH to another flask as a blank. Oxidize and titrate the blank and each flask containing the 20 mg. of cellulose as described above. Suppose the results are V_3 and V_4 ml., respectively; then the equivalence factor (mg. of cellulose per ml. of *N* solution) or mg. of cellulose per 10 ml. of the 0.1 *N* $Na_2S_2O_3$ as used—the portion replaced by cellulose having been oxidized is; $200/V_3 - V_4$.

Note: Take care that the 10-ml. pipet used to deliver the cellulose aliquot is calibrated for the delivery of that solution, since it is more viscous than water. (Using the same 10-ml. pipet as was used for the specimen, will minimize the possible error.)

Note 2: Alternatively, in place of the KI and $Na_2S_2O_3$ titration, after cooling the oxidized specimen to room temperature, add 50 ml. of water to the specimen and to the blank, cool again to room temperature, add 2 to 4 drops of ferroin indicator* and titrate

* Ferroin indicator—1.5 g. of *o*-phenanthroline monohydrate (or 1.6 g. of the hydrochloride) plus 0.7 g. of $FeSO_4$ dissolved in water and diluted to 100 ml.

with a freshly standardized 0.1 N solution of ferrous ammonium sulfate to a purple color. In the calculation above, V_1 and V_2 will represent the volumes of ferrous ammonium sulfate used for the specimen and blank, respectively. An electrometric titrimeter is preferable for this titration.

Note 3: If the alpha-cellulose content is less than 91%, there is not sufficient $K_2Cr_2O_7$ in 10 ml. of the 0.4 N reagent to oxidize the cellulose in the 50 ml. aliquot of beta- and gamma-cellulose taken originally from the 500-ml. flask. Use a 25-ml. aliquot and 25 ml. of 0.5 N NaOH for the blank titration so that the acid to total-solution ratio remains constant.

C. Gamma-Cellulose

Transfer exactly 190 ml. of the original alkaline filtrate to a 250-ml. glass-stoppered graduated cylinder. Add a few drops of methyl orange and fill the graduate to the 240-ml. mark with 6 N H_2SO_4, stopper the cylinder, and invert several times to mix. Adjust to the acid side if necessary by the further addition of H_2SO_4. After cooling, dilute to the 250-ml. mark with distilled water, mix, and let stand at room temperature until the beta-cellulose has settled. This usually requires 16 hr.

Carefully decant the clear solution through a dry folded filter paper into a dry 250-ml. beaker, discarding the first 50 ml. Determine the gamma-cellulose in the filtrate by oxidizing a 50-ml. portion with 10 ml. of dichromate as described above for the beta- plus gamma-cellulose. Make a blank test by substituting 50 ml. of the 0.5 N NaOH for the filtrate.

Calculate the gamma-cellulose as a percentage of the moisture-free pulp as:

$$\text{gamma-cellulose} = \frac{(V_2 - V_1) \times N \times 6.85 \times 1.316}{W}$$

where 1.316 is the aliquot factor, and the other symbols are as before.

Calculate the percentage of beta-cellulose by difference between this and the beta- plus gamma-cellulose.

REPORT

Report the alpha-, beta-, and gamma-cellulose as percentages of moisture-free pulp, to the nearest 0.1%. If the pulp is unbleached, state whether or not the results have been corrected for lignin and ash.

ADDITIONAL INFORMATION

1. The dilution step, following the swelling of the specimen with 17.5% NaOH, has had a troublesome influence on reproducibility. Dilution of the slurry with an equal volume of water as prescribed in T 203 m prior to 1958, has been widely practised. The degree of solubility of the specimen is very senstive to conditions in the range of the resulting concentration of NaOH (9.4%). Accordingly, more dilution water was specified in T 203 m-58 to reduce the NaOH concentration to the present 8.3%. Also the swelling and diluting steps were described in greater detail. 2. The principal changes in this revision over T 203 m-58 are: (a) Additional details of adding the 17.5% NaOH to the specimen are given. (b) Heat is appled to oxidize cellulose in solution with bichromate. (c) A procedure is given for determining the cellulose equivalence factor in its volumetric determination, if desired. 3. Related methods: ASTM method D 588–42 (0.3 g. specimen, add 20 ml. 17.5% NaOH for 10 min., add 33 ml. water, stand for 1 hr. and filter); Swedish APPE methods CCA7, for alpha-cellulose (10-g. specimen, add 50 ml. 17.8% NaOH for 25 min., add 150 ml. water, stand for 5 min. and filter) and CCA 10, for beta- and gamma-cellulose. (ASTM D 588 and CCA 10, prescribe ferrous ammonium sulfate for titrating the oxidized cellulose).

REFERENCES

Report of Division of Cellulose Chemistry of the American Chemical Society, *Ind. Eng. Chem., Anal. Ed.* 1: 52 (1929).

Doree, C., "The Methods of Cellulose Chemistry," 2nd ed., page 363, D. Van Nostrand Co., New York, 1947.

LETTERS TO THE EDITOR

Activated Chlorate

To the Editor, *Tappi:*

This is referring to the paper of Messrs. Rapson, Anderson, and Mullen, which appeared on page 642 in the August, 1959, issue of *Tappi* about which I would be obliged when publishing following comments:

The no. 8 of the literature cited in the paper (as private communication) consisted of a bulletin (available on request).

After remembering that a "pulp" containing but limited amount of noncelluosic matters cannot absorb more than a limited amount of bleaching agent and that also when presenting to a pulp an unlimited amount of any bleaching agent for an unlimited time only a partial removing of noncellulosic matters was possible this bulletin was giving evidence that amounts of bleaching agents practically employed are far below those correspondiug the condition of unlimited amount for unlimited time.

For what concerns the use of activated chlorate these amounts can be so detailed:

1. For a pulp obtained by merely softening a spruce wood in cold alkali up to 16% (pulp generally understood as cold caustic pulp).
2. For a pulp obtained in a similar way from hard woods up to 9%.
3. For a pulp obtained in a similar way from yearly plants up to 4–6%.
4. For a semichemical pulp, e.g., NSSC up to 5%.
5. For unbleached kraft or bisulfite pulps up to 3–4%.
6. For a prebleached pulp up to 1% but generally less than 0.5%

Bulletin was exposing how pulps 1, 2, 3 having originally about the same lignin content of starting material can be further bleached to 90–92 G.E. by simple hypochlorite (or hypochlorite peroxide treatments—Example:

Straw pulp after absorbing 5% chlorate in bleached to 83 G.E. by 6% hypochlorite, mixed hardwood pulp after absorbing 9% chlorite is bleached to 91 G.E. by 11% hypochlorite + 2% Na_2O_2.

To be pointed out that it is quite irrelevant for this process when woods 1–2 are debarked or containing any amount of bark.

For semichemical and ordinary pulps containing much less lignin than cold caustic pulps further bleaching is obviously easier. Example: a kraft pulp (Ostrand) after absorbing 2.6% chlorate can be bleached to 91 G.E. by 0.5% chlorate

and 2.5 peroxide, conserving optimal figures for viscosity strength and color reversion.

For prebleached pulps the bulletin was exposing how treatments of 0.5% chlorate could improve the brightness up to 92 G.E. for kraft pulps (and up to 95.00 for bisulfite) without imparing strength and viscosity.

These figures are lower than those obtained on a kraft pulp as exposed in the Table I on the cited paper, but higher than those obtained by final treatments on ordinary kraft pulps as exposed in the article "The Role of pH in Bleaching Pulp," by W. H. Rapson (*Tappi* 39, No. 5 (1956)).

Reason of this discrepancy is that kraft pulps considered in the above article were ordinary pulps prebleached with chlorine hypochlorite steps while kraft pulp of Table I was a pulp pre-bleached by a concerted sequence comprehensive of previous ClO_2 treatments.

Concerted sequences comprehensive of previous chlorate treatments exist for chlorate too and are exposed in the cited bulletin. By these sequences too a final chlorate treatment in obtaining better results than those obtained by the same treatment applied after a conventional sequence.

In all the considered cases when higher amounts of bleaching agents are presented and absorbed by the pulps, no better results are obtainable and a degrading of pulps is unavoidable.

All the experiences reported by Mr. Rapson in the cited article are made on the principle of an unlimited amount of chlorate presented to a pulp for an unlimited time.

The evidence given that in these conditions the pulp is degraded is therefore so sure as useless.

What is however remarkable is that by such experiences realized without any attempt to titrate the residual amounts of chlorate left unused in the pulp when treatment was interupted, economical conclusions have beeen derived.

As a matter of fact, when presenting (Fig. 9) to a prebleached sulfite pulp, respectively, 0.9% ClO_2 and 1.8% chlorate and observing that after a certain time "Both pulps approached the same maximum brightness and color reversion was the same in both cases" a conclusion economically in favor of ClO_2 was obviously obtained.

Experience could however be made practically with the same results by presenting to the pulp, respectively, 1.8% ClO_2 and 0.9 chlorate thus leading to exactly opposite conclusions.

When considering "step bleaching at room temperature" retention times up to 80 days have been experimented by Mr. Rapson. It must be observed here that when the amounts of chlorate are those above indicated and experiences are realized *at room temperature* there is no more chlorate available in the pulp after 6–8 days.

Chlorate reaction is however an exothermic reaction and conditions of *"room temperature"* are only realizable in laboratory scale (where there is a total dispersion of heat) and uniquely when very little amounts of chlorate are employed. In all other cases pulp is automatically warming itself. As chlorate reaction is following approximately the rules of a second order reaction retention time is reduced to the half of each 10°C. of temperature increasing.

Practically, the retention time for chlorate treatments realized without any apport of external heat is not measured in days but in hours (Example: 12 hr. for the reported reaction absorbing 9% chlorate for mixed hard woods pulp).

Therefore, experiences by which the amount of chlorate presented to the pulp was such that after 80 days there was still chlorate available are to be considered typical experiences of unlimited amount of agent for unlimited time.

Similar experiences realized with hypochlorite would probably lead to the merely disappearing of the totality of pulp tested.

In Fig. 11–12–13 of the cited article a kraft pulp was bleached to 88.1 G.E. with Cl (10%)-NaOH (2%) NaO Cl (2%)-ClO_2 (2%).

The same pulp was presented up to 9% chlorate in a single stage observing (after 40 days) an insufficient brightening and a strong drop in viscosity.

If the aim in this case was really to bleach the pulp to 88.1 S.E. directly by a single step activated chlorate the less that could be said is that such a result has never been claimed.

In another case to a NSSC pulp 12% chlorate were given for two times (always without any end titration) constating that the pulp was only reaching 28 G.E. Here the only question is why Mr. Rapson has limited himself in giving twice 12% chlorate. By giving twice or three times 50% or more chlorate result would not have been different but somewhat more impressive.

About the uses of activated chlorate in chlorination example given in the cited article was: a kraft pulp after an ordinary bleaching sequence Cl_2-NaOH-H, reaches: 67.3 G.E. (60.3 after aging) 22% alc. sol. 9.2 viscosity by same conditions after adding in chlorination 0.5% activated chlorate figures were 69.6 G.E. (61.6 after aging) 15.7 alc. sol.-15.7 viscosity. That means: an increasing of 2.3 points brightness, an increasing of 1.4 points after aging, a reduction of about 30% in alkali solubility, an increase of about 72% in viscosity.

These advantages were judged "not large enough to justify the cost of the chlorate" (0.5% activated chlorate). It must be observed however that Mr. Rapson when exposing in the cited article the case of a NSSC pulp is using 0.5% ClO_2 by the chlorination. According to the article of W. H. Rapson and C. B. Anderson (*Tappi* 41, No. 9 (1958)) it appears that 0.5% ClO_2 in chlorination is far from obtaining the effects obtained with 0.5% activated chlorate.

Evidence is here given that when ClO_2 and chlorate are compared in the same amount, smaller results obtained with ClO_2 are considered favorable while bigger results obtained with chlorate are not.

Dott. Ing. Paolo Marpillero
Azienda Brevetti Industriali
Milano, Italy

Editor's Note: Because of the nature of the above letter, it is published herein as received.

To the Editor, *Tappi:*

Our investigation of the possibility of using sodium directly in pulp bleaching was begun long before we heard of Mr. Marpillero's "activate chlorate" and his suggested methods of using it, for we hoped that the conversion of sodium chlorate into chlorine dioxide could be avoided. Naturally when Mr. Marpillero announced the commercial availability of "activate chlorate" in August, 1957, we investigated the conditions suggested by him then, and also tried out his subsequent recommendations as they become available to us. We appreciate the cooperation that Mr. Marpillero has given us in supplying us with samples of his "activated chlorate" and letters and pamphlets.

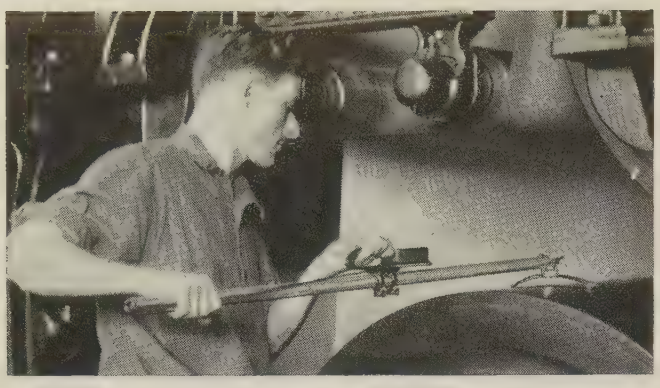
Our experiments were not carried out with any view of refuting what Mr. Marpillero claimed, but rather with hope that chlorate could be used directly to advantage in the pulp mills of this continent.

Our results were presented as objectively as possible, and interpreted to the best of our ability from a technical and economic viewpoint.

We find it difficult to understand many of Mr. Marpillero's criticisms and we leave their interpretation to other readers. We would like only to correct some statements made by Mr. Marpillero.

The statement that all our experiments "are made on the principle of an unlimited time" is not true, as reference to Figs. 2, 11, 12, 13, 14, and 15 will show.

Our experiment in which an NSSC pulp bleached using 0.5% ClO_2 in the chlorination was given only to show that this pulp could be bleached by other means, even though it was not bleached by the chlorate. No suggestion was given that this amount of chlorine dioxide in the chlorination was economically



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justified. Furthermore, in the paper to which Mr. Marpillero refers in which 0.5% ClO_2 in chlorination was used along with other amounts, it was not suggested either that this amount is optimum or that it is justified. On the contrary, more usually 0.05 to 0.10% chlorine dioxide is optimum along with chlorine in chlorination.

We hope that Mr. Marpillero's attempts to persuade the pulp industry to use chlorate directly are successful.

W. Howard Rapson,
University of Toronto
Toronto, Ont.

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RECENT BOOKS

Radioisotopes for Industry. By Robert S. Rochlin and Warner W. Schultz, Reinhold Publishing Corp., New York, 1959. $5^1/_4 \times 7^3/_4$, 190 pages. $4.75.

A review of the applications of radioisotopes, this book presumes the reader to have no previous knowledge of radioactivity and nuclear science. Some of the examples described include the use of radioisotopes in: gaging thickness and density, radiography, wear measurements, leak hunting, and other research and development techniques.

Although the various applications are discussed in broad terms, the appended bibliography provides a useful source of technical information on specific techniques.

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Young technically trained graduate with five to ten years experience in the paper industry to take charge of technical control and service in a Mid-western specialty mill. Exceptional opportunity for a competent and ambitious man with the opportunity to advance to positions of greater responsibility in production. Excellent benefits and a good starting salary. Please reply to P955-60, **Technical Association of Pulp and Paper Industry, 360 Lexington Ave., New York 17, N. Y.,** giving résumé of experience and education as well as references.

SALES ENGINEER

Unusually fine opportunity for a technically qualified salesman who has sold to paper mills or who has had paper mill experience.

The man selected for this position must be able to apply his knowledge of paper making and coating to the sale of specialty starches for all such applications.

The position holds excellent promise for advancement with a progressive company in an expanding program.

Salary open—based on experience and education.

Your inquiry with full résumé will receive immediate confidential attention. Reply to **P959-60, Tappi, 360 Lexington Ave., New York 17, N. Y.**

LOCAL SECTION ACTIVITIES

Meeting Calendar

March, 1960

1 Chicago Section, Chicago Bar Association, 29 S. LaSalle St., Chicago, Ill., "Folding Cartons."
8 Lakes States, mill visit to Bergstrom Paper Co., Neenah; dinner at Menasha Elks Club. Theme: "Statistical Methods Application in the Paper Industry."
8 Empire State Section—Metropolitan District, "Coating."
10 Empire State Section—Northern District, "Strength Development in Paper."
14 New England Section—Eastern District, Armand's Restaurant, Route 9, Framingham, Mass.
15 Ohio Section, Manchester Hotel, Middletown, Ohio, "Two-Phase Flow in a Wet Web," Speaker: Joe Parker, Beloit Iron Works.
15 Ohio Section—Indiana District, Marott Hotel, Indianapolis, Ind., Panel Discussion, to be announced.
17 Empire State Section—Eastern District, Junior Awards Contest.
17 Lake Erie Section, Cleveland Engineering and Scientific Center, "Off-Machine Coating with Emphasis on Waxing and Barrier Types and Base Paper Requirements."
17 Kalamazoo Valley Section, Inman's Restaurant, Galesburg, Mich., "Graphic Arts."
18 Gulf Coast Section, Cove Hotel, Panama City, Fla.
18 Virginia-Carolina Section, John Marshall Hotel, Richmond, Va.
18–19 Southeastern Section, Columbia, S. C.
26 Delaware Valley Section, Benjamin Franklin Hotel, Philadelphia, Pa., 1960 Philadelphia Graphic Arts Conference.
29 Golden Gate District—Pacific Section, "Recent Advances in Materials Handling," 4:00 p.m., mill visit to Nulaid plant. Dinner at Cottage Restaurant, San Leandro, 6:00 p.m.

April, 1960

5 Chicago Section, Chicago Bar Association, 29 S. LaSalle St., Chicago, Ill., "Corrugating."
8 New England Section, Management Night.
12 Ohio Section, Miami University, Oxford, Ohio, tour of the new Paper School. Subject: "High Polymers," Speaker: H. E. Whiteacre.
12 Lakes States Section, dinner, location to be announced, C. J. West Awards.
12 Empire State Section—Metropolitan District, "Packaging."
14 Empire State Section—Northern District, Junior Award Night.
15 Pacific Section, Everett, Wash., Shibley Award Meeting.
19 Ohio Section—Indiana District, plant tour to be announced, "Coating." Speaker: Brag Golding, Purdue University.
21 Empire State Section—Eastern District, Symposium, "Wet End Machine Operation."
21 Kalamazoo Valley Section, Inman's Restaurant, Galesburg, Mich., "Stock Preparation."
28 Delaware Valley Section, Engineers Club, Philadelphia, Pa., E. J. Albert Award Program.

May, 1960

3 Chicago Section, Chicago Bar Association, 29 S. LaSalle St., Chicago, Ill.
5–7 Pacific Section, Bellingham, Wash., or Harrison Hot Springs, Annual Meeting.
10 Pacific Section—Golden Gate District, Hotel Claremont, Berkeley, Calif., True Memorial Lecture.
12 Kalamazoo Valley Section, Harris Hotel, Kalamazoo, Mich., Recognition Night, WMU Awards.
12 Empire State Section—Northern District, Annual Ladies' Night.
12 Ohio Section, Hartwell Country Club, Cincinnati, Ohio, Ladies Night.
13 Gulf Coast Section, Jung Hotel, New Orleans, La.
13 Empire State Section—Metropolitan District, Ladies' Night.
17 Ohio Section—Indiana District, Marott Hotel, Indianapolis, Ind., "Testing." Speaker: Arthur Dreshfield, The Glidden Co.
20–21 Virginia-Carolina Section, Wilmington, N. C., mill visit to Riegel Paper Corp., Acme, N. C.
20–21 Southeastern Section, Savannah, Ga.
21 Empire State Section—Eastern District, Annual Ladies' Night.
27 Delaware Valley Section, Beloit Eastern, Downingtown, Pa., tour and outing.

June, 1960

3–4 New England Section, Chatham Bars Inn, Chatham, Mass., Spring Meeting.
10–11 Empire State Section, Whiteface Inn, Whiteface, N. Y., Annual Meeting.
17–18 Maine-New Hampshire Section, Mountain View House, Whitefield, N. H., Annual Meeting.
21 Kalamazoo Valley Section, Annual Golf Outing, Gull Lake Country Club.

September, 1960

To be announced.
Pacific Section, Salem, Ore., "Modernization."

Maine-New Hampshire

The following paper was presented at the meeting of the Maine-New Hampshire Section of TAPPI held in Portland, Me., Oct. 23–24, 1959.

Ceramics in Centrifugal Cleaning Equipment

D. H. Kohlhepp

Some of the more recent ceramics developed in connection with high temperature materials technology have excellent abrasion and corrosion resistant properties. These qualities have been demonstrated, for example, in their use as pump impellers and nozzles under extremely abrasive condi-

D. H. Kohlhepp, Black-Clawson Corp.

tions. Their use in machine tool bits has been a commercial success for many years. More extensive application is being found daily as the properties of these unusual materials are recognized and tried. A new approach is required in design using ceramics because of their unusual physical properties.

The selection of ceramics as a material for the liners in our line of liquid cyclones was made as the result of extensive comparative tests conducted in a board mill under exacting mill conditions. In the summer of 1957, we noted severe wear appearing in the metal cones on all the centrifugal cleaners in this mill after only a few months operation. Four were medium pressure, 1000 g.p.m. cleaners located in the beater room after the hydrapulpers on filler stock. Nine high pressure cleaners, 500 g.p.m. each, were on the machine ahead of the Selectifier screens. The furnish, mostly wastepaper, was loaded with sand, metal, glass, plastic, and rubber, all in various degrees of sizes and shapes, down to fine silt.

The general arrangement of cleaner, screen, and pumps around each vat is shown in Fig. 1.

A cleaner pump provides 500 g.p.m. stock at 0.8% consistency to the cleaner at 50 p.s.i. Accepted clean stock in required amount is diluted with whitewater to vat consistency at the fan pump which discharges to the vat through a Selectifier screen. The screen provides uniform fiber dispersal

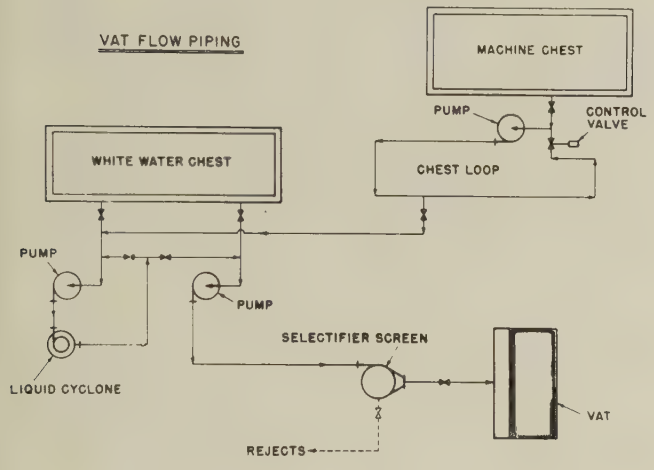


Fig. 1

and final removal of small particles of foreign material such as plastic rubber and cork which are less responsive to centrifugal cleaning (Fig. 2).

Figure 2 is the nonplugging Black-Clawson liquid cyclone. Down to the bottom of the top cone, this illustrates a typical free vortex type cyclone. The stock to be cleaned is introduced under pressure through a tangential inlet located at the top of the cone. A downward spiraling motion is imparted, carrying the stock toward the apex of the cone at increasing high velocities and high centrifugal force.

The high specific gravity and specific area materials are carried downward. The dirt and a portion of the stock exit to the lower chamber. This is actually square at its top and round at the bottom, designed to decelerate the dirt and stock particles and permit settling action into the bottom collection chamber. Stock is reclaimed in the lower cone so that there is very little fiber loss.

This particular design has a very pronounced wear spot just above the apex opening of the cone at the point of reversal of the cyclone.

The original design of cleaner used replaceable metal cones having a $^1/_4$ in. wall thickness, some wearing completely through after only 3 months running or a wear rate of 1 in. per yr.

Figure 3 is an enlarged cross section of the top cone wall. The wear starts in the area beginning approximately 1 to

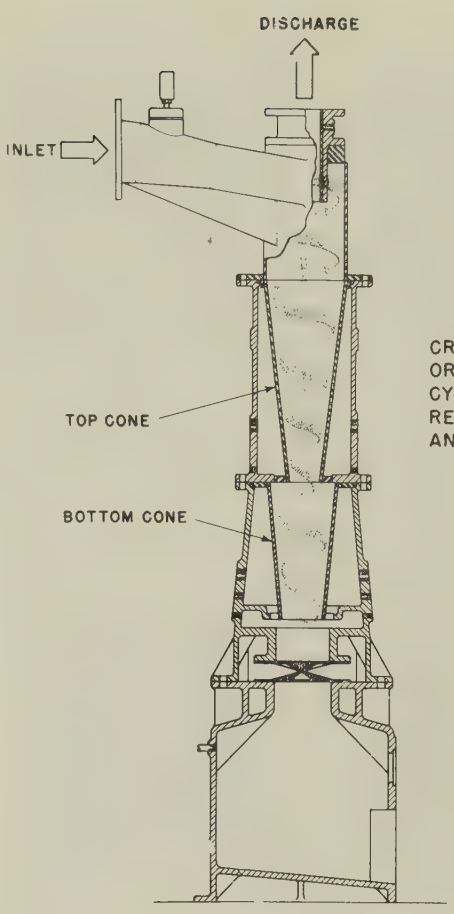
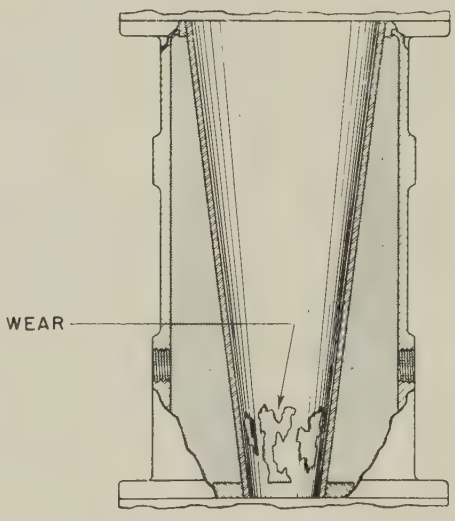


Fig. 2

2 in. from the bottom and extending upward 2 to 4 in. Once a small wear pattern develops in this area, it progresses upward.

Figure 4 illustrates actual cones taken from the cleaners within this mill which have been cut into halves. Several metals of recognized wear resistant properties had been tried previously in the replaceable cones. Figure 4 is typical of their condition after a few months operation. The larger cone is stainless material. The smaller one is a high carbon alloy steel.



ENLARGED CROSS SECTION OF TOP CONE SHOWING WEAR PATTERN

Fig. 3

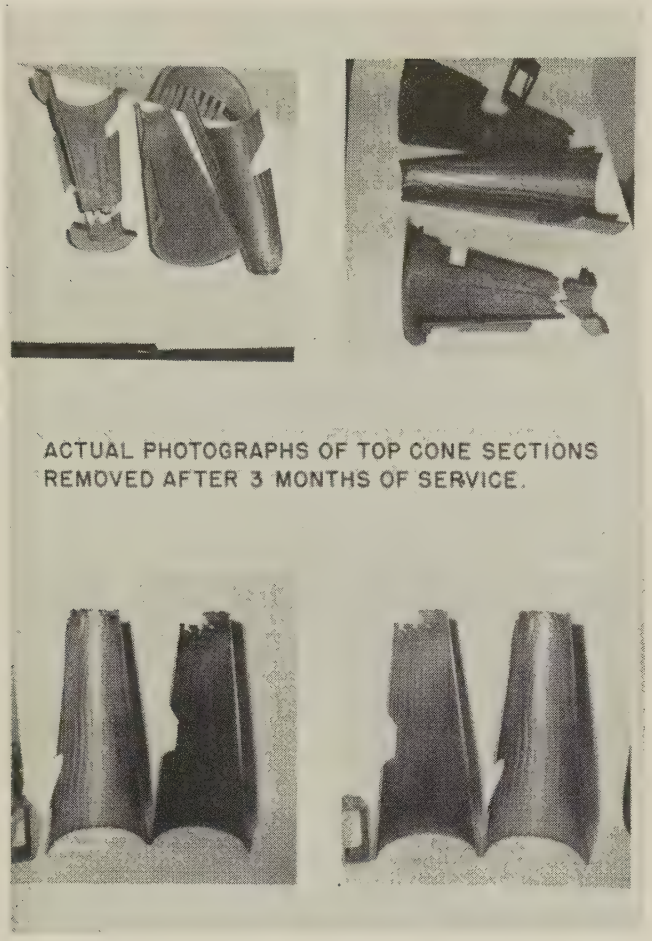


Fig. 4

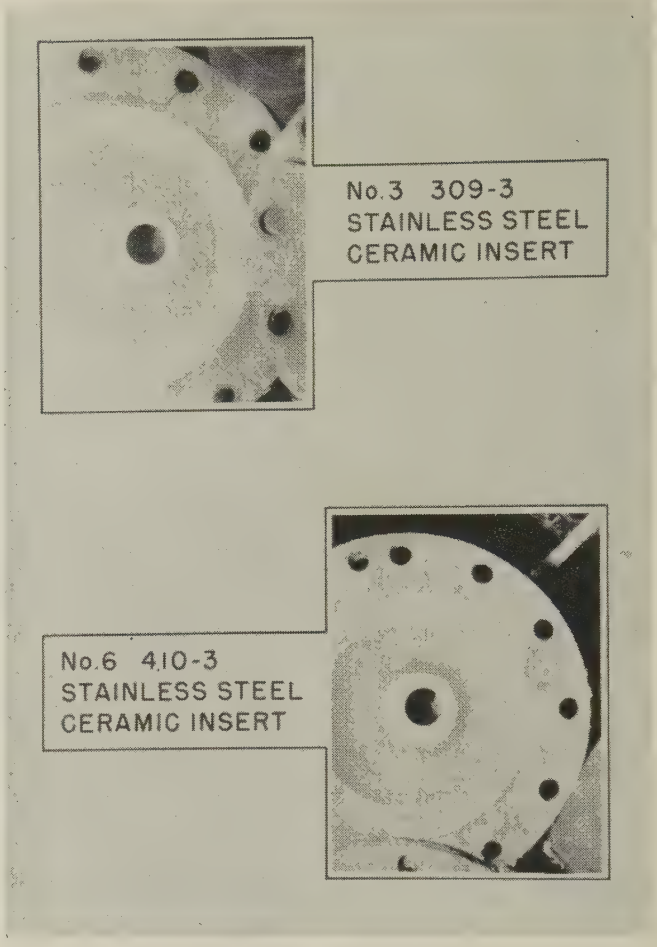


Fig. 6

Although these examples were discouraging, the mill was experiencing a high degree of dirt removal with this type of cleaner. The product quality was excellent, so no design change or alterations to cone proportions was attempted in order to improve wear conditions. (This, of course, is possible for example by continuing the cone tip on down and employing a continuous type bleed.) Instead, a better material for this service was sought, evaluating in the mill, using the nine cleaners which were located on the machine. They are arranged as shown in Fig. 5.

Note that no. 1 and 2 cleaners are on the backliner cylinders, no. 3 through 7 are on filler, and no. 8 and 9, topliner. Alum and size is present from no. 3 on with the pH down around 4.5. Bottom and top cleaners 1, 2 and 8, 9 handle furnish which has had little previous cleaning other than classifiner screen. Sand and grit content is high. The filler cleaners, no. 3 through 7, are on furnish that has been centrifugally cleaned once at $1^1/_2\%$ in the beater room cyclones.

Test materials were installed in each of these cones as an insert in the lower third of the cone, the most critical wear area. Materials for test were selected from four general categories: (1) metal, (2) rubber, (3) plastic, and (4) ceramic.

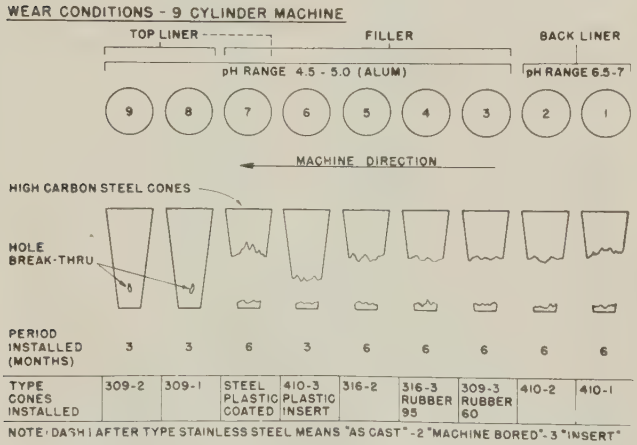

WEAR CONDITIONS - 9 CYLINDER MACHINE
TOP LINER
FILLER
BACK LINER
pH RANGE 4.5 - 5.0 (ALUM)
pH RANGE 6.5-7
9 8 7 6 5 4 3 2 1
MACHINE DIRECTION
HIGH CARBON STEEL CONES
HOLE BREAK-THRU
PERIOD INSTALLED (MONTHS) 3 3 6 3 6 6 6 6 6
TYPE CONES INSTALLED | 309-2 | 309-1 | STEEL PLASTIC COATED | 410-3 PLASTIC INSERT | 316-2 | 316-3 RUBBER 95 | 309-3 RUBBER 60 | 410-2 | 410-1
NOTE: DASH 1 AFTER TYPE STAINLESS STEEL MEANS "AS CAST" -2 "MACHINE BORED" -3 "INSERT"

Fig. 5

Fig. 7

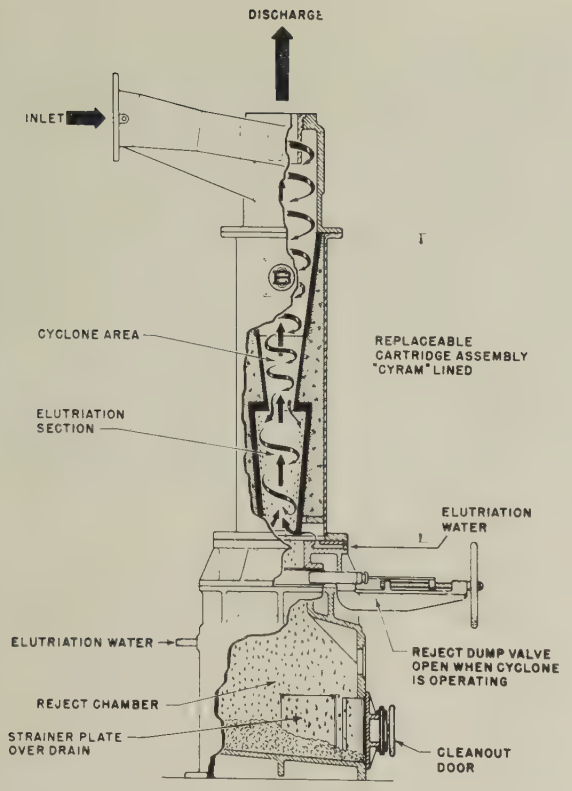


Fig. 8. Manual reject

Inserts were made of several materials from each of these groups, chosen for their known wear and corrosion resistant qualities in other similar applications.

The first inspection was made after the inserts had been in place and operated for 2 months. Our measurements revealed wear rates on the metals of from $^1/_4$ to 1 in. per yr. A failure had occurred on one of the plastic inserts and on one rubber one. Another rubber inset, a polyurethane series

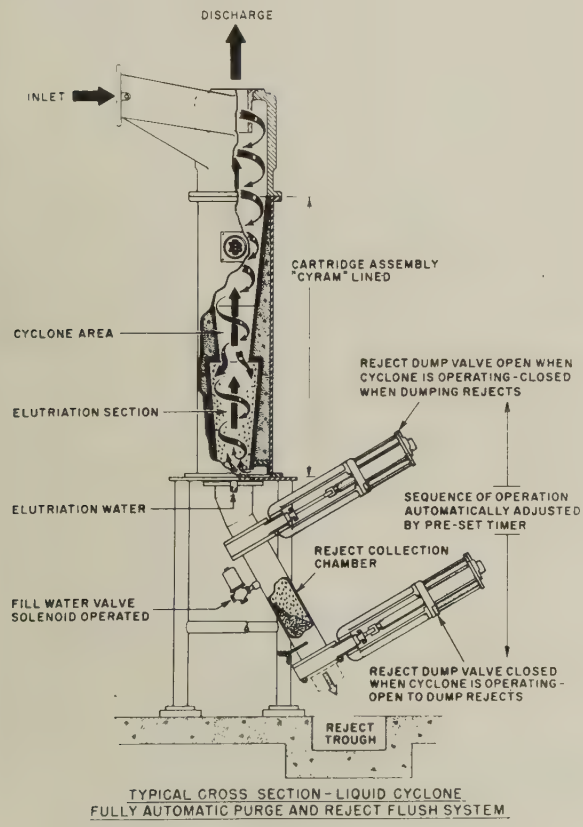

DISCHARGE
INLET
CARTRIDGE ASSEMBLY "CYRAM" LINED
CYCLONE AREA
REJECT DUMP VALVE OPEN WHEN CYCLONE IS OPERATING - CLOSED WHEN DUMPING REJECTS
ELUTRIATION SECTION
ELUTRIATION WATER
SEQUENCE OF OPERATION AUTOMATICALLY ADJUSTED BY PRE-SET TIMER
REJECT COLLECTION CHAMBER
FILL WATER VALVE SOLENOID OPERATED
REJECT DUMP VALVE CLOSED WHEN CYCLONE IS OPERATING - OPEN TO DUMP REJECTS
REJECT TROUGH
TYPICAL CROSS SECTION - LIQUID CYCLONE FULLY AUTOMATIC PURGE AND REJECT FLUSH SYSTEM

Fig. 9. Automatic reject

SOME PROPERTIES OF BLACK-CLAWSON CERAMICS

MECHANICAL PROPERTIES	CYRAM NO. 1	CYRAM NO. 2
TENSILE STRENGTH	23,000 P.S.I.	3,000 P.S.I
COMPRESSIVE STRENGTH	270,000 P.S.I.	20,000 P.S.I
MODULUS OF RUPTURE (1/4" ROD)	42,000 P.S.I.	5,500 P.S.I.
MODULUS OF ELASTICITY	31,000,000	17,000,000
DENSITY (LBS./CU. FT.)	220	170
POROSITY	VACUUM TIGHT	6% - 8%
HARDNESS (MOH'S)	9	9.6
(KNOOP)	1,650	2,000

Fig. 10. Mechanical properties of CYRAM no. 1 and no. 2 at normal temperatures used in the paper making process. 70 to 200°F.

approx. no. 95 durameter, looked very promising and was continued in place. The ceramic insert showed no measurable wear and was continued. The high wear metals were replaced with other samples. Test was continued for another 6 weeks. Still no wear was evident on the ceramic insert, but definite wear patterns were started and measurable in the others.

Figure 6 shows ceramic insert test pieces after period of 3 months' operation. Other ceramic inserts were installed and the tests continued for a period of a year with still no wear. The final design using two types of ceramic metals was evolved and tested meanwhile with excellent results.

There are actually two different types of ceramic materials used. At the critical wear area, is a liner of very dense, fine grain material, designated Cyram* no. 1, having a Moh hardness of 9 or almost as hard as sapphire, and next to diamond. (Diamond cutters are employed to machine the fits.) The ceramic material used in the other portions of the cleaner is approximately the same hardness, Moh 9, but is a less dense material and somewhat coarser granular structure, designated Cyram no. 2. These liners or cone sections are assembled on a jig bottom up (Fig. 7). An outer casing is lowered over them and the cavity between casing and cone filled with a special cement.

The finished cleaner is shown in Figs. 8 and 9. There are five sizes of cleaners, ranging in diameter, as measured at the large end of the cone on top, from 6 to 14 in. having capacity 250 to 1000 g.p.m.

The thermal properties of these materials are well established but of little significance here. Mechanically, they have relatively high tensile and compressive strength, particularly Cyram no. 1, and low porosity. Their chief disadvantage, in common with all ceramics, is lack of ductility. Modulus of elasticity, at lower values of stress, however, is only slightly above that of steel for Cyram no. 1, slightly over one half for Cyram no. 2. The shape of a centrifugal cone section is ideally suited to the characteristics of these materials, provided they are properly seated. Uniform wall thicknesses are employed throughout with no sudden changes in contours, and very desirable from a manufacturing standpoint for control of out of roundness and warping tolerances. We have had to be satisfied with the top cones made up in sections. A one-piece cone would have too long a length to diameter ratio, and would bell out or sag in the furnace. We use a diamond ground butt joint, with good results. Field inspection reveals no eroding or galling or other trouble at this juncture.

After 2 years of experience with ceramic materials in this design, we can report complete confidence in its properties and its future use in your equipment.

* Copyright 1959 Black-Clawson.

Presented at the Maine-New Hampshire Section of TAPPI, Portland, Oct. 23-24, 1959.

PAPERS PRESENTED AT THE CORRUGATED CONTAINERS SESSION II

44th Annual Meeting of the Technical Association of the Pulp and Paper Industry

WEDNESDAY, FEBRUARY 25, 1959

New Revolutionary Concept in the Art of Corrugating Paperboard—The New and Old Compared

H. W. WILSON

During the October, 1955 TAPPI Session I delivered a paper titled "An Operator's Thoughts on Flute Contour." In that talk I brought out some of the inherent problems that the industry is having in corrugating with modern single facers. I believe the most significant statement was the amount of indention or compression of the corrugating medium at the nip point between the corrugating rolls, and that this compression of the medium combined with the larger rolls had caused impairment within the corrugating teeth, preventing the necessary flow of medium to form flutes properly.

Considerable study has been made over the last few years in regard to this indenting which is inherent in corrugating paper. It is best explained in this manner; corrugating rolls, as presently operated, in theory do not run at fixed centers, but with their centers changing. This is because instead of rolling on a true concentric line they are rolling as if they are running on a number of flat surfaces, as that of a symmetrical polygon, with the number of sides equal to the number of teeth. If a straight line is drawn over the top of two teeth and the center lines of the teeth passing through the center of the roll form the outside legs of an isosceles triangle, the straight line becomes the base. We then bisect this triangle and it can be seen that this line that bisected the triangle is shorter than the lines formed by the teeth. The net difference between these two lines is the amount of travel that a pair of like diameter corrugating rolls must change pitch centers in order to operate. Because of mass and rotational speed, very little actual change takes place in the pitch centers, but nevertheless a compensation has to be made.

This compensation takes place in the medium by compression and indenting. In order to analyze more thoroughly we term this change in running pitch center as the "drop action." The amount of drop action naturally is different for different diameter rolls, as well as being different for the same diameter rolls when a change in tooth circumferential pitch takes place, that is A, B, and C flutes.

Our experience and experimentation indicate that a combined drop action of 0.0015 on B flute to just over 0.002 A flute is the minimum drop that will allow flow of the medium without impairment, and that the maximum allowable drop is approximately 0.003 on B flute and 0.004 on A flute. If we exceed these maximums it appears that the drop action is so severe that the flute sidewalls are ruptured.

In operating a conventional corrugator it is necessary to load the so-called top corrugating roll. This loading usually will be in the neighborhood of 75 to 150 lb. per line inch depending upon the width and diameter of the rolls. This represents a range of 2400 to approximately 5000 lb. p.s.i. that is being applied to the medium at the nip point while corrugating. With this loading and because of the "drop action," the medium being a semiplastic, will indent further than necessary to compensate for the change in pitch centers. We have another variable, the medium itself—its ability to sustain a load. A soft medium will indent more, a hard medium less, however, in either case the medium will spring back somewhat and is therefore originally compressed and indented more than is necessary to compensate. To further aggravate the situation, conventional corrugating rolls operate alternately with the tip of the tooth of one roll meshing into the valley of the other, and the rolling diameter of the corrugating rolls is approximately halfway through the tooth depth. This means the intermeshing tooth tip is always traveling at a greater peripheral speed than that of the valley. This overspeed of the tip, and resultant burnishing action, added to the necessary loading, elongates the medium at the nip point and adds to the indenting. By actual measurement, for example, a set of rolls that required approximately 0.002 indenting to compensate for the "drop action" measured over 0.0045 indenting after corrugating. Undoubtedly the medium was compressed more than this figure, the medium being a semiplastic, would recover some of its caliper by the time it could be measured.

By diminishing the caliper of the medium at the nip point subsequent impairment occurs restricting the flow of medium to satisfy the takeup factor of the flutes coming into impression. The indenting of the medium at the nip point allows the rolls to come closer together and reduces clearance in the teeth coming into impression. This, then restricts the flow of the medium which will try to force the rolls apart, which requires more load to form the corrugation which causes more indentation, and so on in a vicious circle. The result of the "merry go round" is a cause of tooth wear and non-

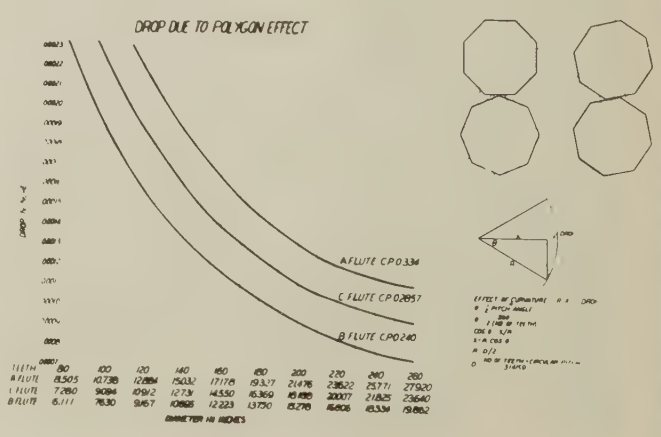


Fig. 1

H. W. Wilson, Royal Container Co., San Francisco, Calif.

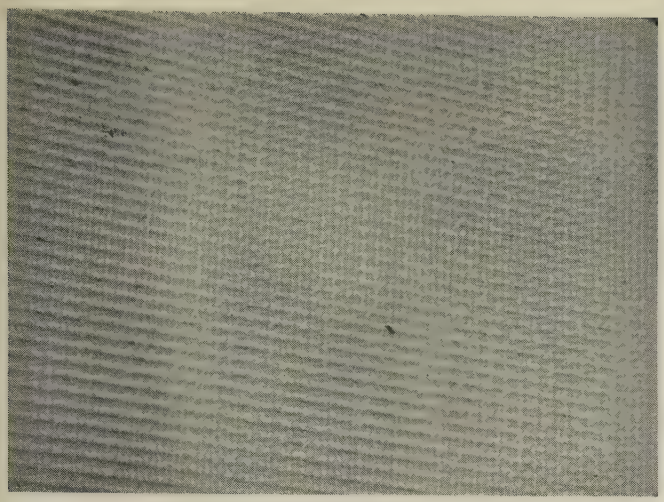


Fig. 2

uniformity in the finished board. Figure 2 illustrates some of the effects of this sliding action. Notice the undulating configuration along the length of the flutes.

To illustrate this deformation of tooth or flute as well as maceration, leaning flutes, and "highs and lows" we have made an enlarged drawing (Fig. 3) of corrugating teeth depicting the running position of a set of rolls 12 in. diam. for conventional operation for B flute, 50 corrugations per foot, to reflect a finished board height 0.125 using 42 lb. liners. This drawing was made with sufficient side clearance so that there would not be sidewall impairment. We show the nip point at $4^1/_2$ thousandths separation because our measurements of actual high quality corrugated medium show this to be the maximum separation under running conditions.

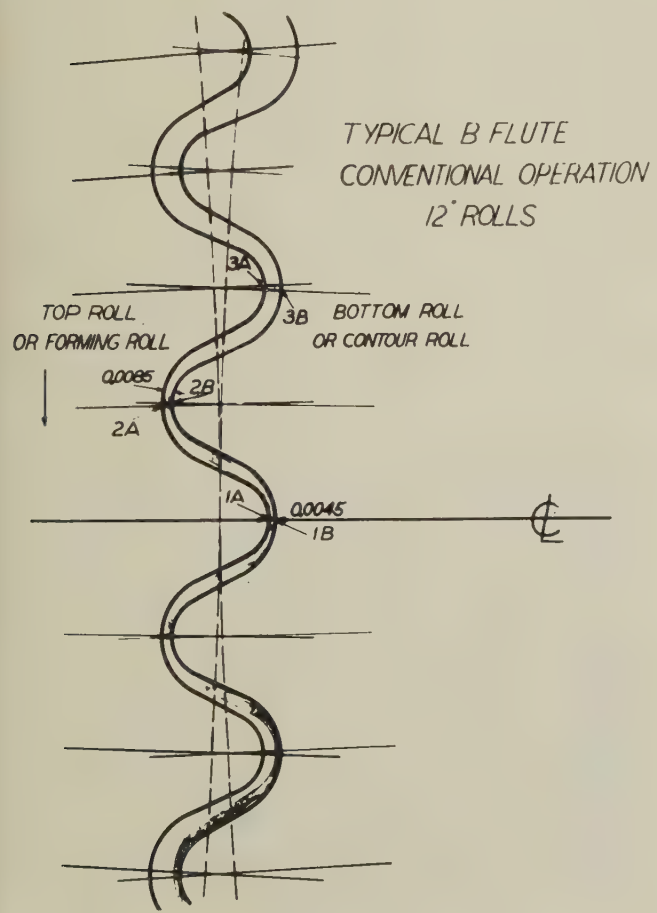


Fig. 3

The center lines of the tips and valleys are numbered 1A, 1B, 2A, 2B, 3A, 3B. The line between centers of the corrugating rolls is at 1A and 1B. The second position at 2A and 2B is under compression. Actually the medium in the second position started under compression before 1A and 1B were on the center line. Impairment occurred when the clearance was the same or slightly greater than the original caliper of the medium. This being the case, the paper required to complete the flute, as 1A and 1B rotate into the center line, comes from stretching the paper between positions 1 and 2. If the medium is sufficiently plasticized a normal flute may be formed. If it is not plasticized the stretch may tear the paper causing maceration, or the paper may stretch and spring back causing "high and lows" or leaning flutes. In all cases the flute had been weakened.

While 1A and 1B are in line, 2A and 2B are at some angular distance apart at the paper line and because of the difference in radii between the tip and valley, there results a difference of peripheral speed This difference of peripheral speed is also true at the nip point and even more critical at the nip point.

The difference means that the tip has to travel more distance going under load than its valley and again the same distance as it goes off the center line. Its action to the medium causes relative movement on each side of the medium which we term as slide action under load. This certainly adds to the indenting problem as well as wearing the tips of the corrugating rolls, causing loss in flute height. As roll diameters are increased, this situation becomes worse, causing more positions to become impaired, which then tends to deform the metal itself, because as paper becomes compressed to a certain point it will actually indent the metal, resulting in deformed single face. Naturally, there is a limit as to how large a set of corrugating rolls can be made. We definitely know it is impossible to corrugate on a flat plane such as using two flat gear racks, the reason being, flutes would have to be formed by actual stretch of material and not by flow of material. We are faced with this more or less to some degree, when there is more than one corrugating position under pressure.

In addition to these problems another not quite so obvious but a definite effect in corrugating takes place. As we corrugate the compression and slide action tends to close up the pores and burnish the medium and make it more dense. This compressed medium cannot absorb adhesive as readily and most of the adhesive is squeezed to the leading and lagging edge of the flute going past the pressure roll. Actually the best bond is obtained where most of the adhesive is retained within the fiber structure in the material at the very tooth tip.

We, as well as you, are being faced with greater quality

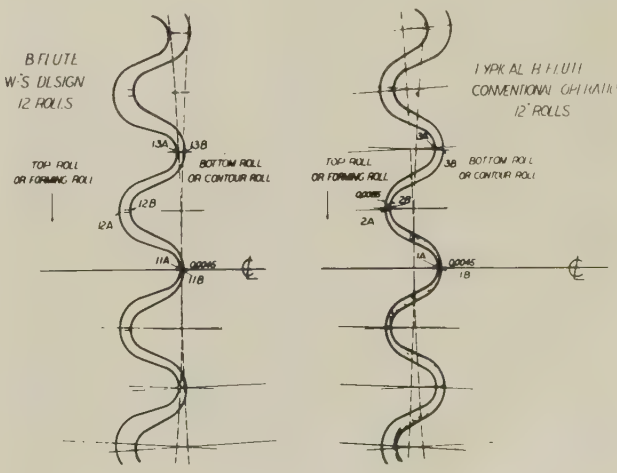


Fig. 4

demand by our customers. Lower cost desired by our owners led us to collaborate with S&S Corrugated Paper Machinery Co., in an investigation of a fresh approach to corrugating. This study has been taking place over the past four or five years. After analyzing, experimenting, and prototyping, a new concept in corrugating has been developed. Figure 4 illustrates the new concept compared to the conventional, the scale for both being identical.

In Fig. 4 is an enlarged view of the new concept. 11A and 11B as before are on the line between roll centers. The separation at this point is 0.0045. Note that 12A and 12B on the new concept are at a greater distance apart than 2A and 2B of the conventional rolls. This was accomplished by recessing the valley of the top or forming roll beyond the point where it could possibly come in contact with the medium at any time. The top corrugating roll is now driven by its tips through the paper by the valleys of the bottom or contour roll. The elimination of alternate tip-to-valley, valley-to-tip contact drive of conventional operation allows the rolling diameter to be at the paper line and not halfway through the tooth depth. The rolling diameter being at this point means that the valley represents the rolling o.d. of the bottom or contour roll and the tips of the top or forming roll represent its rolling diameter. This eliminates any differential in speed between the tip and the valley as they come into contact and consequently there is no slide action. The difference in speed, as represented in area 12 by lines 12A and 12B, is no longer a detriment as there is no contact between these surfaces. The elimination of slide action at the contact points eliminates wear from this aspect. What wear will appear, either from paper abrasion or cold working, will have these effects; wear on the contour roll will tend to maintain flute height. Wear on the top roll will have no effect on the finished board unless the tips wear to the point where the valleys of the forming roll come in contact with the tips of the contour roll and the action then would be that of a conventional roll operation. This condition is possible but highly improbable, based on our experience at this time.

Note 13A and 13B is now the second point of impression. The lines 13A and 13B cross through the medium indicating no slide action or relative motion. While 11A and 11B are at their approximate indented position, 13A and 13B the second position, shows ample clearance, indicating no impairment to the flow of the medium which will minimize "highs and lows" and maceration. This clearance of 13A and 13B would appear in the second position on conventional rolls of 6 in. diam., or the clearance at 2A and 2B of the conventional rolls, would appear at 13A and 13B of rolls 24 in. diam. This is a very interesting point. Using the new concept, our calculation indicates that A flute rolls of approximately 24 in. diam. are possible without sacrificing runnability. This does not necessarily mean that each roll must be 24 in. diam., but that any combination of diameters up to 48 in. could be utilized. On B flute this would allow rolls of 19 in. diam. or 38 in. overall.

Some of the benefits derived from this concept are: stronger structural corrugations by elimination of the slide action and a better single face bond. This better single face adhesive bond is the result of the fibers of the medium being opened as the medium is folded over the tips of the contour roll, and since these tips are not compressed and burnished as in conventional operation, more of the applied adhesive tends to remain on the very tips as liner contact is made under the pressure roll.

The first production set of corrugating rolls using this concept, which is called the WS design, went into operation approximately in December of 1957. Since that time several sets have been put into operation. Royal Container Co. installed a set of B flute rolls in June of 1958. These rolls have been very carefully checked to analyze wear or any physical change. At every 5 million lineal ft. casting impressions were taken from the same position on each roll,

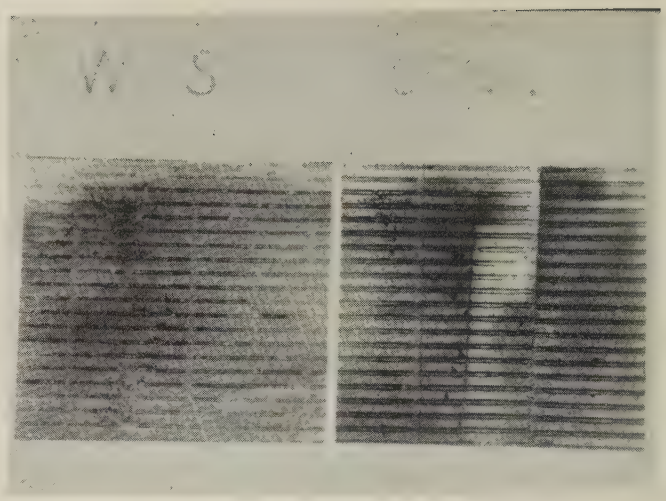


Fig. 5

that is, drive, center, and operating sides. The impressions were checked against a segment that was ground as part of the original rolls. For better interpretation and relative understanding, the same instruments were used for all measurements. At 20 million lineal feet, the contour roll clearly showed no decrease in height and the top roll no measurable change. Projecting this experience, certainly indicates considerably longer life.

Up to now this has been a semitechnical talk, however, "the proof of the pudding is in the eating." Since installing this new set of rolls at Royal Container the corrugator operators now prefer to run these B flute rolls in preference to conventional rolls. The reasons are: a more trouble-free and easy operation. Operating speeds have been increased by the operators of their own volition; practically no adjusting is necessary in changing various types of medium, heretofore various mediums predicted certain speeds and a number of adjustments, these same mediums now work well at full speed. Warp has been greatly minimized due to less stresses applied to the medium while corrugating. Better single face bond, which is more noticeable on heavy weight boards; also less waste due to ease of operation.

The results from this set of corrugating rolls have been outstanding and very gratifying, producing quality material with minimum waste and warp at speeds that were impossible on the rolls they replaced.

In conclusion is shown Fig. 6, single face manufactured at 650 f.p.m. on this new concept. Notice the uniform symmetry and the straight line along the length of the flutes.

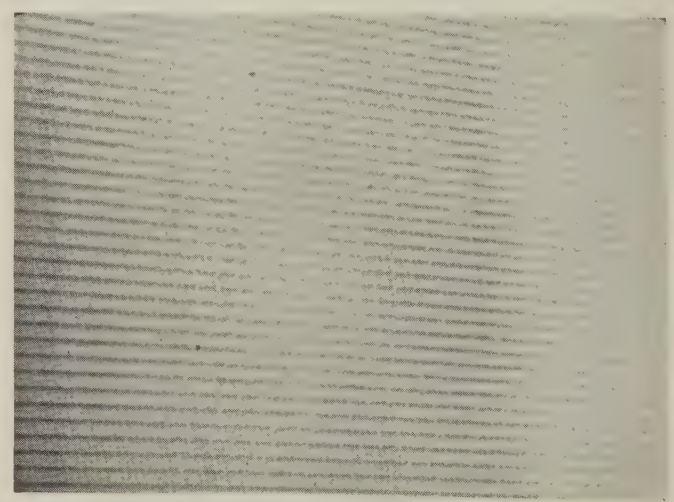


Fig. 6

Now that a new concept has been developed with the WS design, we can look for further developments in the art of corrugating by the utilization of the WS design, faster speeds, higher heat transfer, less roll deflection, and a new method whereby the single-face bond will approximate that of the double backer.

Presented at the 44th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 23–26, 1959.

The New Greenwood Quick-Setting Multicolor Printer-Slotter

WILMER W. WAGNER, JR.

It is indeed a pleasure for me to come before you and outline to you the story behind the development of this new machine and to show you the details of its operation and to discuss many of its features and advantages. I sincerely believe that it is the first basically new idea of operation in printer-slotters in the past 30 years and that it is a machine which will fill a definite need of the corrugated box industry.

First, I would like to tell you something of the history of the development of this press and something of the thinking which went into its development. I have felt for many years that one of the greatest needs in our operation at the Eastern Box Co. in Baltimore was to have a printer-slotter which could be set up quickly so that we would be able to run production operation more than 50% of the time. In talking to many others around the industry I found that this condition prevailed virtually everywhere. In the course of my discussions with other manufacturers I heard and discussed many ideas for accomplishing this. These ranged from removal and replacement of press rolls, premounting on changeable shells on through ideas to have duplicate press rolls in the machine which could be rotated. All of these ideas had merit but none seemed to me to have the complete answer which I was seeking.

Finally, several years ago, I decided to proceed with the idea of designing a completely new press. Before doing this, however, I talked with all of the existing manufacturers of printer-slotters and determined that there was nothing in the nature of what I had in mind in prospect in the immediate future.

As the next step, I laid out on paper the design of a press which I felt would accomplish the various objectives which we were seeking to accomplish. After a period of further refinement of the ideas I decided to approach one of the existing manufacturers of printer-slotters to see if they would be interested in converting my basic ideas into a final design and to follow that by actually building one of these units for our operation. My choice for this was the Greenwood Engineering Co. of Baltimore. This choice was quite logical for many reasons. First of these was the high regard which I hold for Henry Greenwood after many years of association with him, first with his former employer and later with his own company. Secondly, I have been most impressed with the quality of press that his company has built in recent years. Today, his firm is the second largest builder of presses. Finally, the location of the Greenwood Co. in Baltimore was most desirable for the many engineering conferences which the development of a new machine of this type would entail.

Therefore, I contacted Mr. Greenwood and we discussed the details of the new machine and he showed an immediate and enthusiastic response. In a short time the details of the plans for engineering and building the machine which I am about to show you were worked out. The actual final design work took over a year but it was done in sections so that manufacture began well before the final drawings were completed. When you see the machine you will see how this was possible. Actual building of the press took approximately 6 months and final installation was completed in January of this year. It has now operated for over one month.

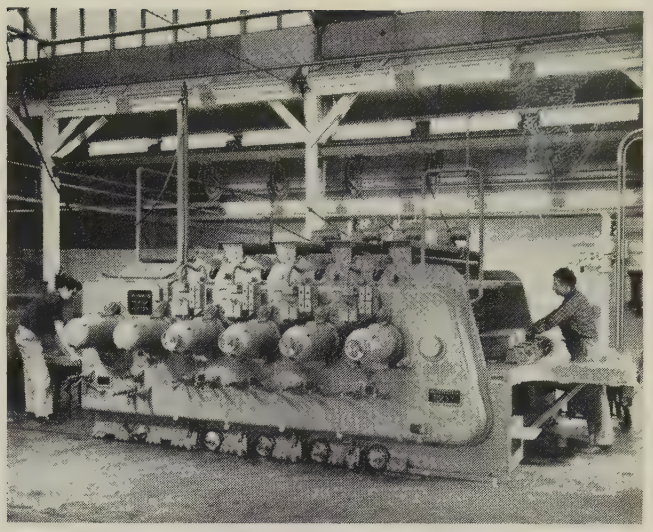


Fig. 1. Side view of press as operating four-color machine

That pretty well tells the story of the history of the development of the press and now I would like to show you the machine itself. Figure 1 shows the side view of the new printer-slotter closed up and in position to operate as a four-color press. In this view it looks quite similar to existing four-color machines. It is well to note, however, the clean uncluttered lines of the press and the ready availability of the controls on the operators side of the machine. Another thing which is apparent is the complete absence of any raised or projecting rails anywhere around the press to interfere with the movement of men or materials.

Figure 2, believe it or not, is the same machine which you just saw. Here it becomes apparent that the new press is radically different from any built previously. This is how the new Greenwood printer-slotter looks when it is running a plain box. It is nothing more than a high-speed plain slotter with a certificate stamp attachment. There are no extra draw rollers, pull strips, pressure adjustments, or other set-ups to be made on printing sections. It is the cleanest, easiest set highest speed machine ever made to run plain boxes.

Figure 3 shows the press as it appears to run a single color job. Note the compact high efficiency appearance of the

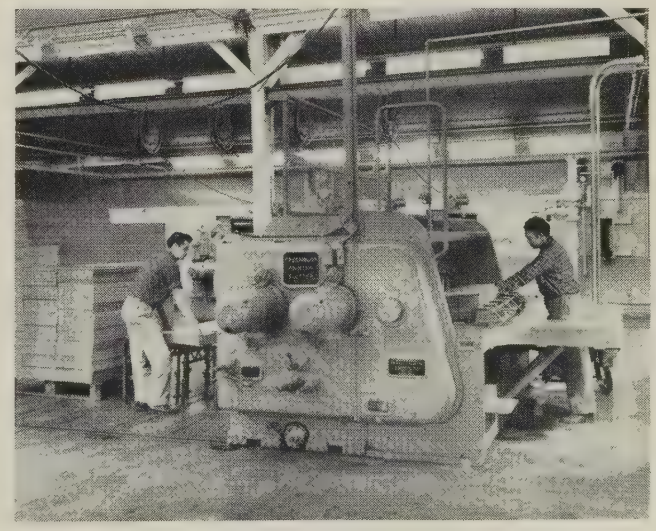


Fig. 2. Side view of press as plain slotter

Wilmer W. Wagner, Jr., Vice-President, The Eastern Box Co., Baltimore, Md.

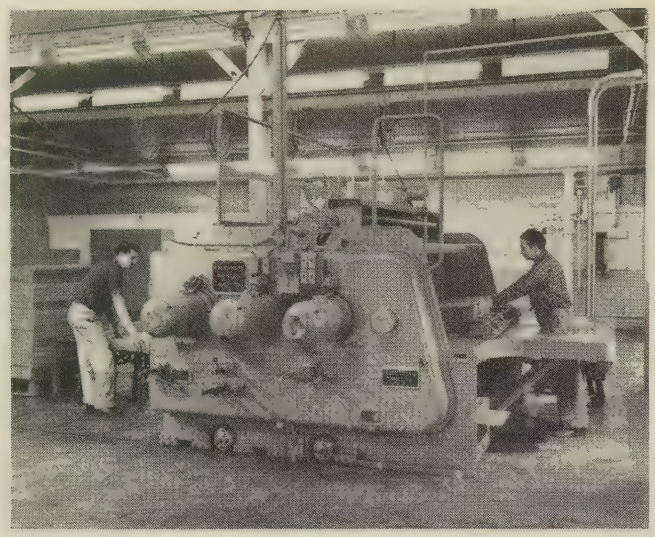


Fig. 3. Side view of press as single-color press

press. Once again we have a unit which represents the most desirable form of machine for running the job at hand.

Figure 4 shows the press as a highly efficient two-color printer-slotter, just as compact and, as I will show you later, considerably more exacting in the quality it can turn out, when compared with any of the present two-color presses in use.

Figure 5 shows the same machine but now it has become a three-color machine, fully equipped to turn out the finest of close register three-color printing.

Figure 1 shows our press as a full four-color printer-slotter. As such it is able to turn out the closest register work and to maintain the finest ink distribution that should be required in any corrugated box plant. I believe that the previous photographs have graphically demonstrated the extreme flexibility of the new machine as a working tool in any box shop.

Figure 6 shows one of the printing units employed in the machine. The entire unit is completely removable from the press itself. These units, which are fully self powered, are removed to the side when not actually in use. Thus, at no time does this printer-slotter employ more printing units than are actually called for on the particular job being run. I would like to briefly discuss the thinking behind this idea. If you furnish the means of changing press cylinders you do gain the advantage of presetting dies, it is true, but this accomplishes only part of your setup requirement. If you remove both the cylinders and ink fountains and rollers

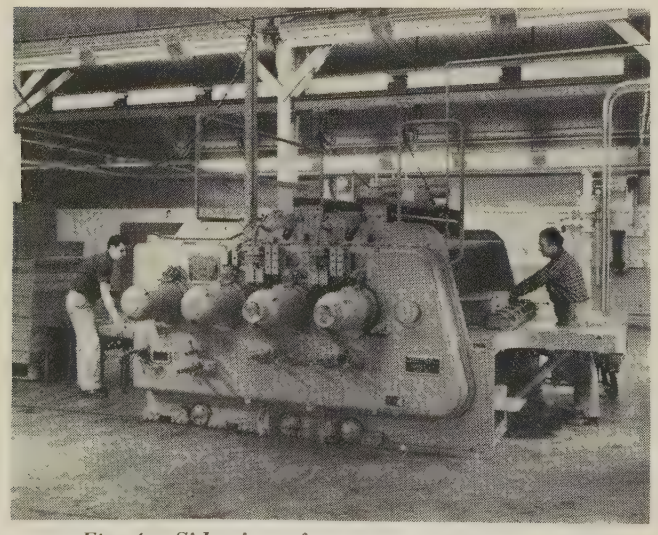


Fig. 4. Side view of press as two-color press

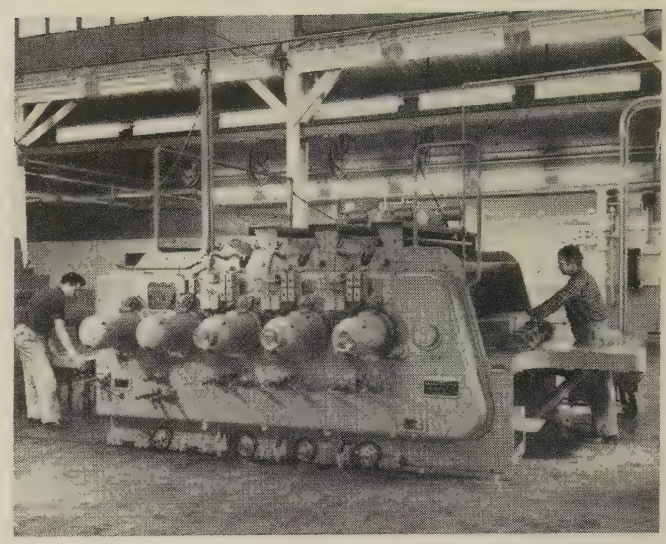


Fig. 5. Side view of press as three-color press

you can accomplish still more but you would still be unable to set draw roller, impression roller, and ink distribution for the next job. Also, you would still leave the base in the machine of any units which might not be needed for any particular job. Therefore, we have gone all of the way and have provided the means of removing the entire printing mechanism complete with all items which must be set up for the following job. As you can see, these units are compact, measuring just 22 in. across the face. They are extremely sturdy, each one weighing approximately 6 tons, and they are fully powered so that they not only move in and out of the machine by push button but they also can be run from their now separate drive motor when out of the machine. I will cover one of these units in detail and explain its various mechanisms.

Now, I would like to explain the new Greenwood printer-slotter from the feed end to the slotter section. I will explain the base on which the press operates from Fig. 7. This base consists of a series of tracks which are set flush with the

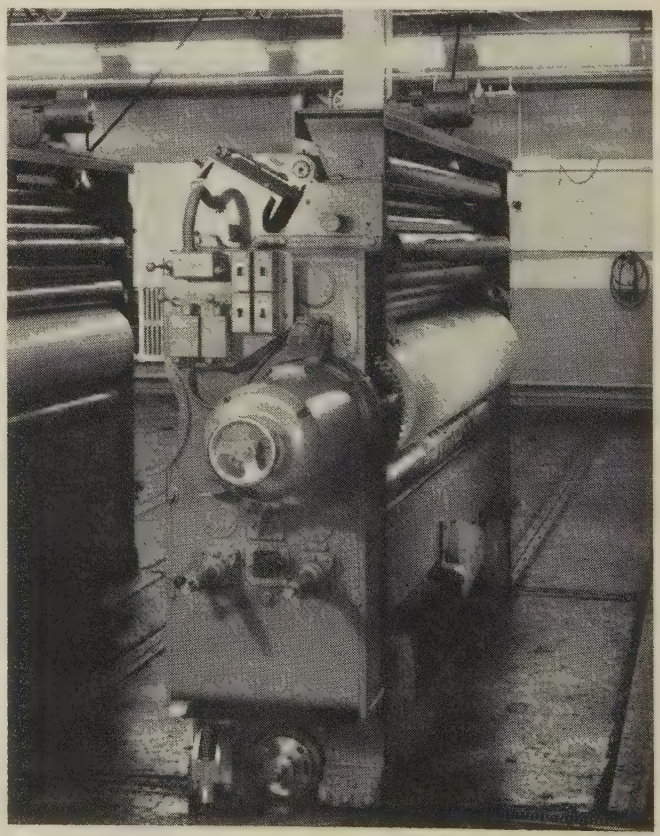


Fig. 6. Angle view of one-print unit from operator's side

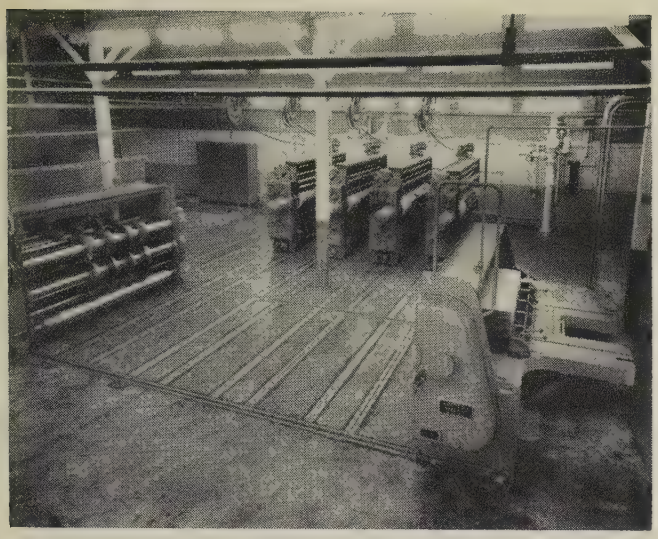


Fig. 7. Elevated view of all tracks

floor. These are of heavy steel with leveling and adjusting screws along their entire lengths. These adjusters are for the purpose of leveling at installation only. The track layout consists of two main tracks which are 26 ft. long and are parallel with each other and separated by the width of the press. The main tracks may be clearly seen in line with the feed and slotting sections. Down the middle of each of these tracks is a rack. Pinion gears are meshed with this rack on each side of the movable units of the press. Also visible in this view are the five pairs of side tracks which are used to remove the units from the main machine. One of each of these pairs has a groove down its middle which acts as a guide for the large wheels on which the units roll out. The five pairs of tracks are for the four print units and the die cutter unit which is not yet in place on this machine. These tracks are long enough to completely clear the units not in use in any time. I will show the actual manner of usage of these tracks as I examine the separate segments of the machine.

Figure 8 shows the feed table of the press. It is just that and nothing more. You will notice that no part of the printing mechanisms are included with this section. This unit is the only part of the whole machine which is fastened to the base permanently, it being bolted to pads at the end of the main tracks and held square with the machine. All of the other units come to this section and butt up tight and square to it. It contains the main drive motor and the head of the main gear train. The feed table employs a kicker feed into a pair of extra large feed rolls. The bottom roll is knurled steel and the top is slotted rubber. These rolls are not directly geared to each other but are driven through a four-gear train which throws their thrust toward each other instead of apart. This definitely helps hold the rolls in contact with the sheet as it feeds. The top roll is held down by two large air cylinders to prevent rebound from the entry of the sheets. The control for these cylinders is located in the upper left-hand corner above the feed table. Since this action is basically a hold-down action there is virtually no consumption of air and only a moderate pressure of about 20 lb. is required. The kicker slides on the table ride in double V tracks which allow for very simple adjustment for wear as needed. The back pile holder for the hopper incorporates the flip-up disengagement mechanism which allows the operator to raise his pile and stop feeding of sheets without stopping the press at any time he desires. One difference on this unit is that a separate timing ring projects through the guard housing on the operator's side of the machine to time the drive on this section with the rest of the machine since no printing unit is incorporated with the feed to time from. As you can see, this feed section is very compact and coupled with one of the print sections it is no larger than the customary feed table and print unit combination.

Figure 6 shows the operator's side of one of the print sections. At the very top is the fountain motor and the catwalk. Below them is the ink fountain and the ink feed rollers. Next is the press roll and then the impression roll. Beneath the heavy side frame cross members are the lifting and roll-out mechanisms. On the operator's side are four on-off switches. Three of these are simply the relays for the drum switches and are turned on at the beginning of the day and off at the end. The fourth switch turns the drive motor for each unit on and is used only when the print unit is out of the main press to drive the individual unit for ink clean up, ink distribution, and for proofing. The three drum switches shown here are for interchanging the units. The switch on the right moves the unit back and forth on the main tracks. The handle moves in the direction it moves the unit. The top switch is used to elevate and lower the unit from the mesh of the pinions in the racks, at the same time engaging or disengaging the large lateral drive wheels with their tracks. I will show you how the mechanism controlled by this switch works in a moment. The third switch rotates the large wheels to run the section in and out of the machine. Again, it also moves in the direction which it controls. The large projecting housing on the side of the print unit is the electric compensator for register adjustment and is controlled by this forward and reverse button. Finally, the controls below are the pressure adjustments on the impression roller and draw collar shafts. At the bottom of this side of the section is the pinion gear which drives the unit backwards and forwards

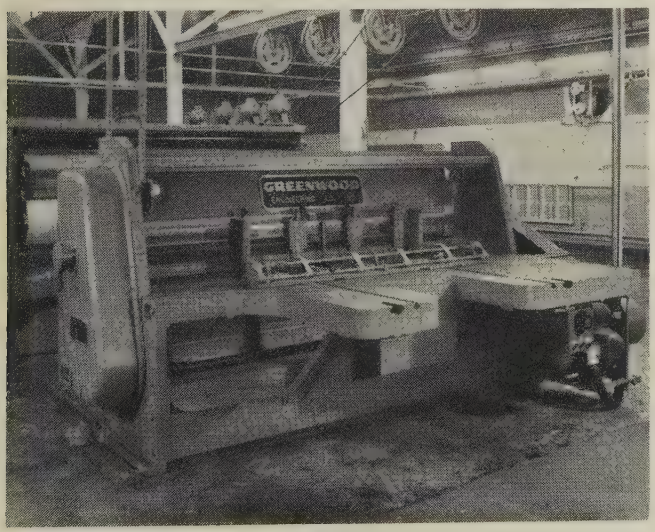


Fig. 8. Angle view of feed end table from feed end

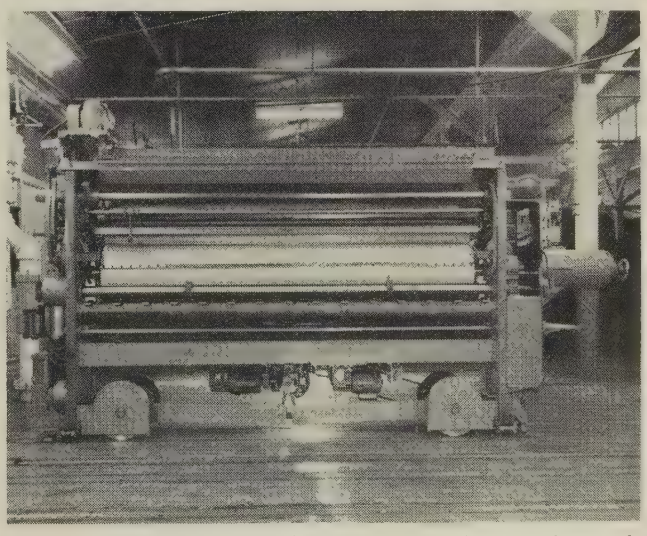


Fig. 9. Full side view of slotter side of one-print unit

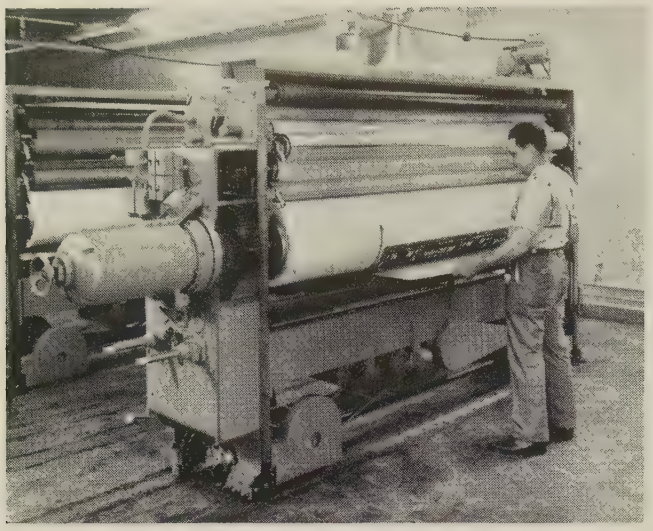


Fig. 10. Angle view of feed side of one print unit with proofing

on the main rails and beside it is the foot treadle used to position the unit in line with the tracks for transfer.

Figure 9 shows one of the print units removed from the main machine as viewed from the slotter end side. At the top is the fountain with the levered adjustment screws. This leverage linkage makes them very easy to adjust and very sensitive for ink control. Also, it turns all of the screws to the top of the machine so that all units are available for ink adjustment while the machine is running no matter how many colors are being used. Below the fountain is the automatic wash-up mechanism which completely cleans the ink rollers in less than 2 min. As can be seen this is built in as an integral part of the printing section completely contained within the frames. Next is the main print cylinder which shows the set in metal strip for holding pre-mounted dies. The dies are first mounted on a Greenwood die mounter, into which a similar strip has been incorporated and a center line clearly marked. When the dies are placed on the press unit the backing is butted tight to the back of the metal slot and the center line is centered with the one marked on the press cylinder. Thus, the dies, which have been proofed on the die mounter at the time of their original mounting, are quickly squared and centered with the press and will hit in perfect register with their first impression. Underneath the main cross members may be seen the lifting and roll-out mechanisms. The lift consists of a gear motor driving a crank which moves the two long levers. These lever arms raise and lower the large roll-out wheels. When a print unit is in operating position in the press, these large wheels are in raised position clear of all tracks and the floor. In this position the pinion gears are in mesh with the main rails and racks. To remove the print unit is run down the main track until it is in line with the pair of tracks onto which the operator wishes to place it. It is locked into position directly over the transverse rails with the foot treadle which, when it is depressed, also allows the elevating mechanism to work. The switch for this elevating motor is then raised and the large wheels are brought down onto the side rails and in the process the pinion gears are raised out of the racks. This then frees the unit to move sideward and the switch is now pushed which makes the wheels move this section to the side of the main machine. By using exactly the reverse sequence, any unit which is out of the machine may be brought in and placed in the main press. The four printing units employed are identical in every way and may be placed on any side rail or may be brought into the machine in any sequence desired. Thus the operator has complete flexibility of usage of all of his printing sections available at all times.

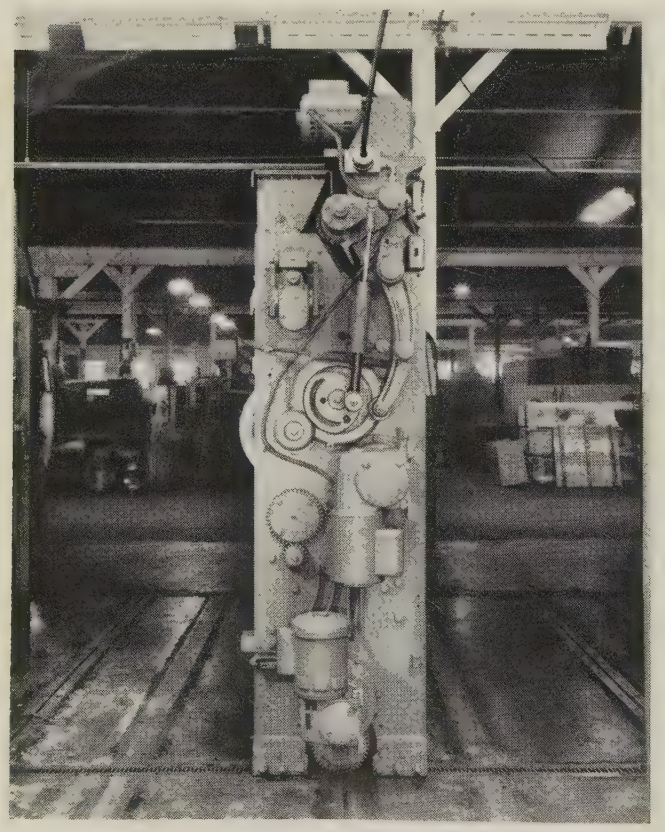


Fig. 11. Motor side of one print unit

Continuing with the print section explanation, Fig. 10 shows one of the print units from the feed table side. In the view shown, the operator has just completed making a setup. His ink is distributed, his dies are mounted, and his pressure adjustments have been made. Now, operating the unit with its own drive motor he is passing one of the corrugated sheets to be used on this order through the unit for proofing. At either side of the sheet he is feeding are two small side guides which he has quickly set to insure him of centering the sheet for proofing. He now passes the sheet through this unit and then takes it to the other unit or units to be used on this job and by having all of them set with the same settings he obtains a completely registered and colored proof exactly as it will look when run through the main press. Any adjustments to be made will be made here on the side and not in the press itself. When this unit moves into the main press to run the job it will have ink in the fountain which will have been distributed to the dies, dies will be in place and proofed and all pressure adjustments and draw collars will be set. This represents not only a great saving in time but also, we have run many jobs where there was not a single waste sheet for printing register or coverage at the press. Over a period of time this waste saving will pay for a major portion of the cost of this printer slotter.

In concluding the discussion of the print unit section Fig. 11 shows the motor side of the machine. At the top is the gear motor which drives the ink fountain roller. This drive is used for clean-up, for ink distribution, and for heavy ink coverage if needed. On the end of the fountain roller is a one-way clutch which is linked to the feed cam with an adjustable link mechanism. With this adjustment it is possible to obtain an infinite adjustment in the stroke of the clutch within its limits merely by turning the link. The turning of the knurled link alters the amount of free travel within the link on each stroke. The small lever behind the feed arm enables the operator to disengage the ductor roll from the fountain roll. The pull-out latch on the ductor throw arm will disconnect the feed arm when it is pulled out. The motor in the middle of this side is the drive for the entire unit when it is out in the setup position. The limit switch and

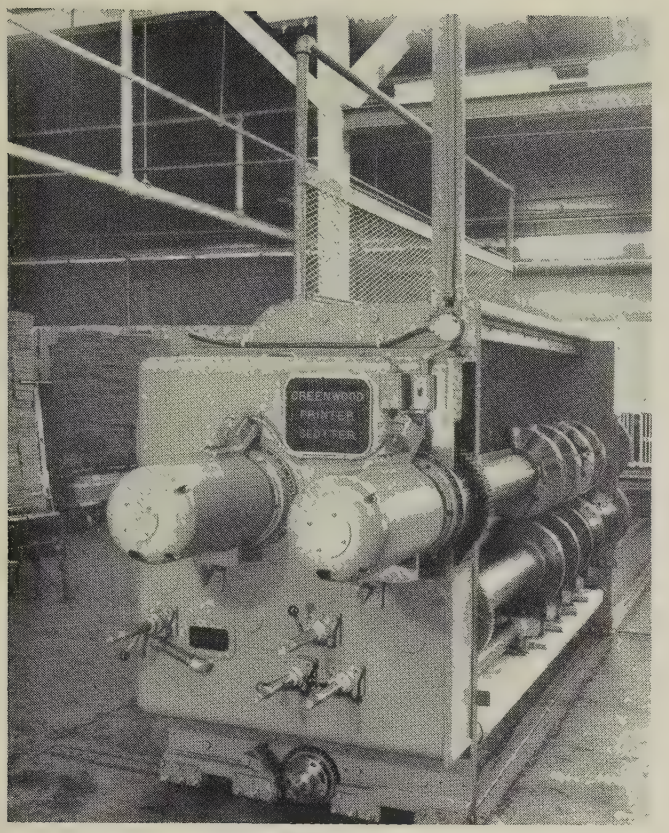


Fig. 12. Operator side view of slotting section

pad shown near the bottom of the sides of the frame is a cut off for this drive motor to prevent it from operating when the unit is locked in the operating position in the printer slotter. This is so that these motors cannot be accidentally turned on and burn out from attempting to drive the whole machine. At the bottom of this side is the gear motor and pinion which furnishes the power to drive this unit up and down the main tracks. Limit switches prevent this motor from running except when the individual unit is in the lowered position in mesh with the racks. Thus, this drive is kept in time with the teeth of the main track when it is removed. A similar limit switch prevents the side wheels from running when the section is in its lowered position.

Figure 12 is a view of the slotting and scoring section from the operator's side. This unit moves up and down the main tracks to make room for the interchange of the print units. The single switch controls these movements. It will be

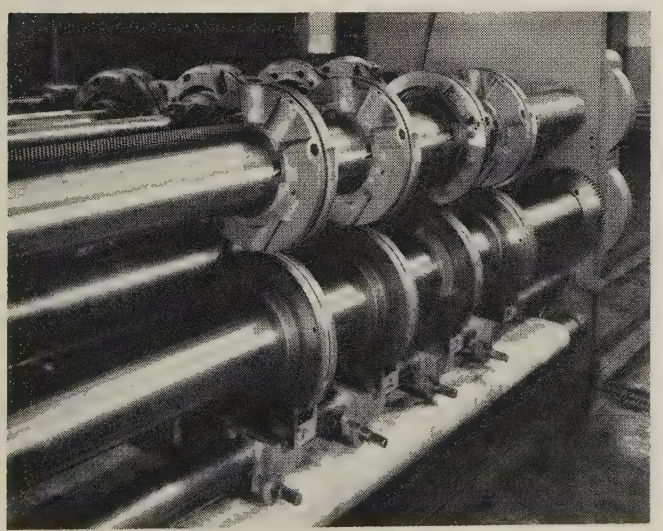


Fig. 13. Angle view of slotting and scoring heads

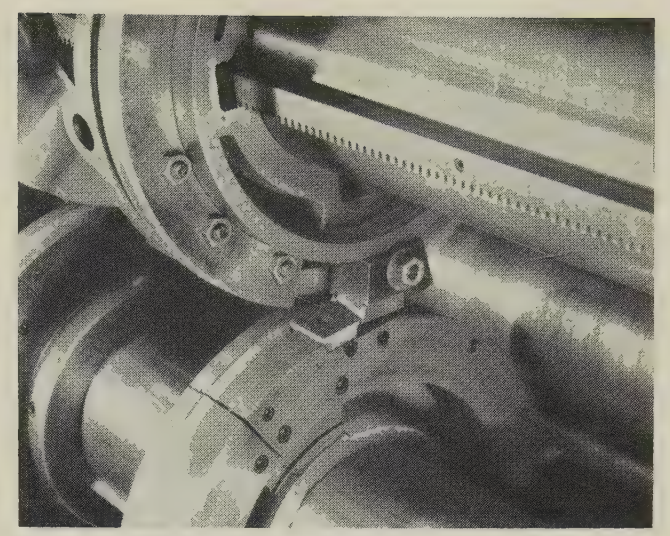


Fig. 14. Close-up view of stitch head

noticed that there are two electric compensators on the unit. These control the setting of the two pairs of main slotter shafts. The reason for two pairs of shafts is that we have employed two complete sets of slotter heads. Each set of heads holds just one of the two slotting knives. In other words, the one slot is cut with the first pair and the other is cut by the second pair. With the heads arranged in this manner it is not necessary to set any knife blades in order to change orders. The operator merely sets the compensator scales for the depth of slot desired and by thus rotating the heads to each other the desired depth and placement of slots is obtained. The design of the heads will be clearly shown in Fig. 13. Below the compensators are the pressure adjustments for the shafts. At the bottom of the unit is one of the drive pinions which moves it up and down the rack.

Figure 13 shows the slotting and scoring heads. This clearly shows the single knife blade on the top heads with the female cutting slot on the bottom. Also shown is the fact that the knife takes approximately 13 in. of the head circumference while the remainder is taken with the scoring ring. The males are on the bottom heads while the female profiles are on the top heads. Both sets of the slotting heads have these scoring profiles so that the scores are actually put in in two stages, the first one light and the second one heavier. This proves of great benefit in obtaining better scoring and folding and allows deeper scoring without score cracking. Of course, when the slotting heads are moved into proper

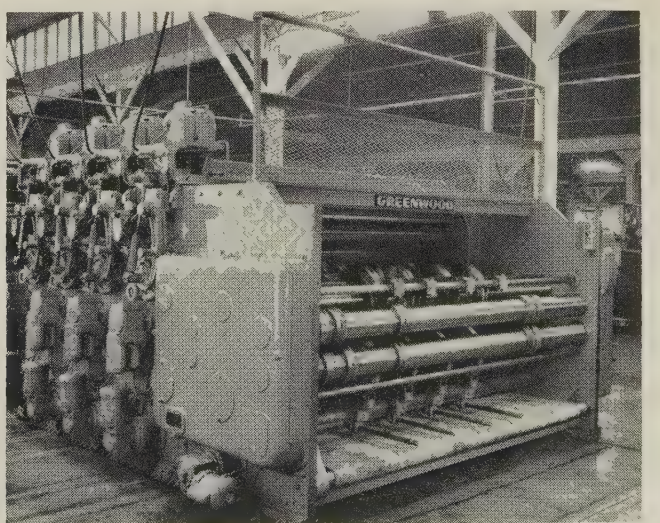


Fig. 15. Motor side of slotting unit from angle at delivery end

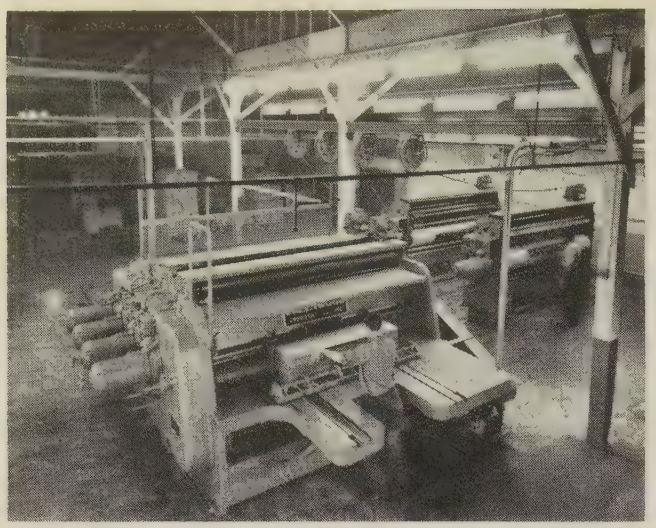


Fig. 16. Elevated view of machine as two-color press with units to side

position the scores are automatically set up at the same time and must always be properly centered with the slots. The bottom row of heads are shown here as yolked together. Since the time of the taking of this picture, however, it has been found that very quick and accurate setups can be made by moving the heads in pairs and the potential maintenance problems in any yolking mechanism have been eliminated. The whole arrangement lends itself to an order change in approximately 5 min. and does a superior scoring and slotting job to that done by a single set of heads. At the delivery end of the slotter is an extra pair of 6-in. shafts on which slitter heads, extra scoring heads, or draw collars for leading into the die cutting unit are able to be placed. These shafts are timed two to one with the press and both sets of the main 7-in. shafts are equipped with one to one heads top and bottom. The extra pair of shafts have given us a flexibility in the scoring area not previously enjoyed. For instance, we have always found problems in scoring double-wall board. By employing extra scoring heads on these shafts we actually form in these scores in three stages and make a much deeper and cleaner breaking score than ever before possible. Also, we often use an extra score here for the stitch lap and find that it gives us a much better breaking lap score. Beneath the slotting heads is a slow moving conveyor belt which carries all of the trim scrap to the delivery end. This slotting section, by virtue of its push through type heads does not employ any strippers of any kind thus eliminating a function which has always proved troublesome in press slotting.

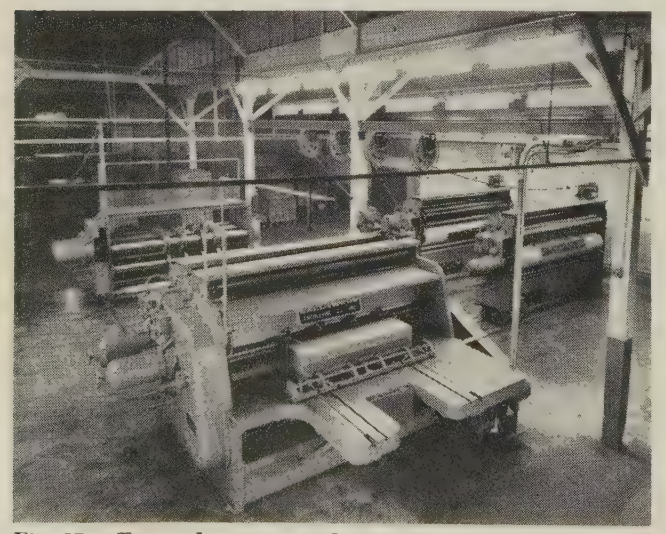


Fig. 17. Two-color press with slotter unit at end of track from above

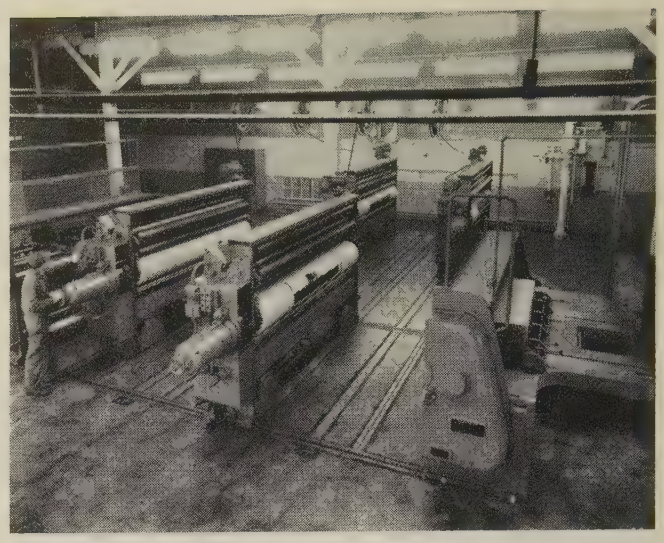


Fig. 18. Same as Fig. 19 with print units at run-out position

Figure 14 shows a close-up view of the stitch lap head. It has long been my feeling that the conventional stitch lap cutter employing a knife against an anvil was inadequate. With the widespread use of the glued lap machines it has become even more important to cut good clean laps. This has become possible with our new arrangement of shafts and heads. We have one lap cutter on a head on each shaft. These move as the heads are set up and thus never have to be set. They are always in line with the slots. Beyond this, however, is the fact that we employ a top and a bottom cutter knife and make a shear cut just like a corrugator cut-off knife. This gives a complete cut on every box. To be sure that these knives cut against each other at all times we have installed giant antibacklash gears on the ends of the main slotter shafts. These gears are of great importance to the whole scheme of this press because, in addition to making the shear cut stitch lap possible, they also make the entire gear train of the machine work against them and have the effect of holding tighter mesh throughout the operation. This has given us an outstanding register of printing and slotting all the way through this printer-slotter.

The anti-backlash gears are contained in the large housing shown in Fig. 15. There are two thumb screw closed ports in this housing which allow easy access to the gears if it is desired to change their tension. At the bottom of the slotter unit on this side is the drive motor and pinion for back and forth movement. The front faces of the gear guards are openings into which the die cutter unit will be meshed when used. This section is now being manufactured but will not be completed for about 60 days. It will employ 9-in. shafts and will be removable for setup just as are the print units.

Having identified the various units which make up the new Greenwood printer-slotter I would like to explain a cycle of operation to show exactly how it works. Figure 16 shows the machine in operating shape for a two-color printing job. It will be noticed that the two unused units are out of the machine where they are being set up with dies and are being made ready for the next order.

Now, let us assume that the order on the press is completed. The first thing done is to run the slotter unit to the far end of the track as shown in Fig. 17. The back end setup men immediately go to work on it from both sides preparing for the next job. The front end feed unit is stationary and the feed man sets the hopper and gates for the coming order and brings the material to be run onto the feed table. Now, while the front and back end men are making their setups, the die set man makes his changes.

Figure 18 shows the die man changing units. He has run the two units which were in use in the machine to their run

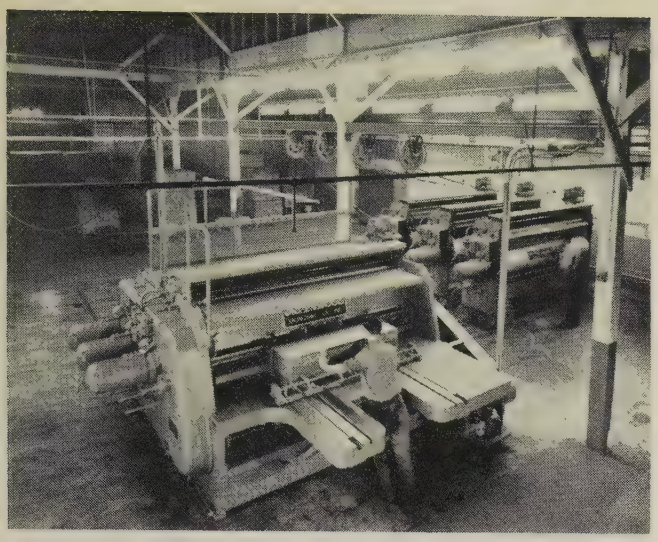


Fig. 19. Elevated view of machine in running position as single color press with three units at set-up stations

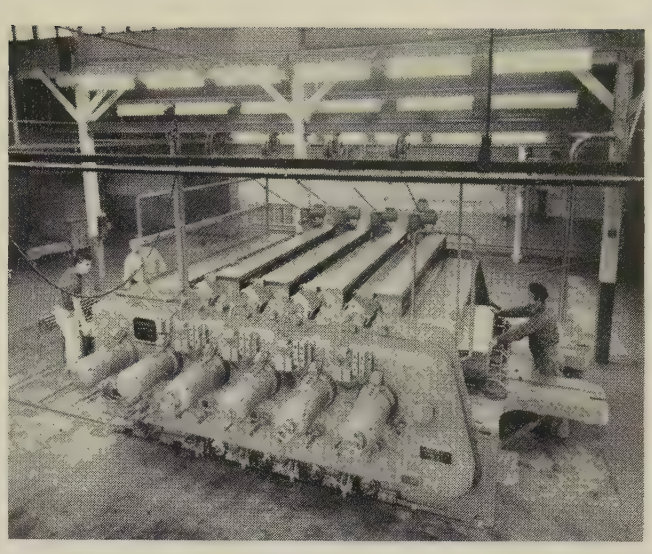


Fig. 20. Machine as four-color press from above

out positions. He then runs them out to the side to be set up for the job after next.

In Fig. 7 we saw all of the units out of the main machine. Whereas the operator ran out the units from the previous order onto tracks 2 and 4 he will now run in the units on tracks 1 and 3 which have already been prepared. He will bring them to the main rails, drop them into mesh, and then move them down the rails tight against the main feed table. The complete interchange of four units takes about 4 min. As soon as the slotter section is prepared it is moved up against the last print section and the press is ready to operate. The entire change of order can be accomplished in 5 to 6 min. The question which may now come to mind is what would be done if a three-color is scheduled. The answer to this is quite simple. For the first time it will actually pay to schedule orders on a printer-slotter. If a three-color order is scheduled you would schedule a single color or plain job ahead and behind it and thus have three units out of the machine for complete setup and proofing.

Figure 19 shows the press in this running position. One unit is in the machine and three are out for setup. For a four-color job a plain order can be run on either side or, if not possible, a major part of the setup could be done on whatever units may be available and then completed on the units in the main machine.

Figure 20 is an elevated view of the complete machine including all four print units. As can be seen, there is a complete bridge of catwalks across the top of the press. The worst hazard to an operator would be to step into an ink fountain. All ink adjustment screws are available from the top and the operator can stand on the slotting section catwalk and watch the boxes leaving the machine and adjust his inks accordingly. The closed up nature of this press allows the operator to place a bucket of the ink he is using on the top of each print unit and he can add as needed or remove back to the pail when the order is completed. This eliminates much of the handling of ink buckets on the machine. There are steps to the top of the press both up the side of the feed table and up the side of the slotting section.

The one remaining question which I have not covered is the matter of power supply for the units. The print units have a detachable twist on plug-in which can be shifted from section to section if desired. In view of the complete interchangeability of the print units this feature prevents any tangling of the leads. The feed table, of course, has a permanent lead to drive the main drive motor. While the print unit leads come from wind-up reels, to take up the slack, this is not necessary on the slotter section since it only moves back and forth on one pair of tracks and thus a permanent lead of flexible line suffices for this unit. The entire press is driven with a 40-hp. Reliance d.c. motor powered by a Reliance V-S unit.

I would like to conclude with a summation of some of the operating results of our experience with this new printer-slotter to this time. Of foremost interest would be a report of our operating ratios. At this time, running orders ranging in size from 500 lots to 20,000 lots we are showing a ratio of from 75% to 80% of our time in actual production. Our programmed target for the machine is 85%. Considering that we are working with new crews who are still not fully acquainted with the press we feel that the above figures are most gratifying. Another fact must be taken into consideration also. That is, that because of the extremely close register which the machine holds, our plant personnel have been running many die-cut jobs on this press with separate heads set on the slotter shafts. As you know this definitely takes more time in setting the slotter section. We have run an average of more than one of these jobs per day. Also, again because of the excellence of register on the press, most of our toughest tight register jobs have been run on it. We have run a number of three-color orders on it and its register has been outstanding, much the best that we have ever seen on a printer-slotter. We expect to reach our 85% operating goal in the next 30 days. We sold two older presses of approximately the 50 by 110 size of this press when we installed the new machine. For the past 2 weeks we have produced more on the new Greenwood than we did in a comparable time on the old ones. The major part of this saving has come from the much quicker setup but the remainder is a result of being able to run all of our three and four-color work, solid band jobs, and specialties in one pass through the machine instead of having to make double passes. We have not run a job through our plant more than one pass since we started the new machine.

The extreme flexibility of the new Greenwood printer-slotter is more apparent every day. For instance, we find that we can run solid fiber beer blanks, display stands, and any other work which requires printing, no matter how elaborate, but needs no creasing or slotting by simply running the slotter section to the far end of the track and employing just the feed table and the number of print units required. Any print unit may be equipped with slitters on the draw roller shafts to slit for this type of operation.

Also, we receive requests for printing proofs on corrugated board from time to time. We run these on the print units out of the machine at a time when the press is on a long run and thus do not have to set up a press in operation to obtain such proofs.

Especially gratifying has been the smooth start-up of this

machine in view of its experimental nature. Already we have run orders as fast as 220 boxes per min. Even at this speed the machine is very smooth and quiet in its operation due to the very heavy gearing and the combination of constant mesh gearing and the antibacklash gears. The feed table operation has been 100% satisfactory from the day of the start-up. Other than some adjustment in the speeds of rotation of the motor for clean-up the press units have been most satisfactory.

The biggest single problem which we have had to lick has been concentrated in the lower slotter heads where a constriction in the cleanout throat prevented us from running boxes with slots longer than 8 in. without jamming. This has been completely corrected with the installation of new complete circle clean-out heads which can accommodate up to a 15-in. slot without jamming.

We have used Perma-Flex ink rollers on all of the print units, both because of their printing quality and especially because of their ease of clean-up. On one of the units we are trying a new type of Perma-Flex covering which at this early date seems to be very satisfactory.

I want to thank you for the opportunity to speak to you and I hope that I have been able to convey to you some of the excitement which we who have been instrumental in developing this new machine feel about it. I hope that you feel that it represents a material step forward in the art of printing fiber boxes and that it may offer you the same opportunities for cost savings in your plant and the same increase in the flexibility of printing operations which we have experienced to date.

Presented at the 44th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 23–26, 1959.

Operating Experiences on the S & S Type C Die Cut Press

DWIGHT M. DAVIS

This paper will give some of the highlights of our experience with the S and S Type C automatic die cutting press.

We received and installed the machine in March of 1958 and have been operating since that time. Our experience with hopper fed die cutters, however, dates back approximately 3 years to our original operation of a Thrissell die press.

I think before we get too far into this subject, a description of the machine in question is in order.

The S and S Type C die cutter is hopper fed, line cutting press. The hopper feed is very similar to the kicker feed of the ZA automatic taper or the ZLG glue lap. The two distinguishing features of the hopper are, the ability to raise or lower the back sheet supports to compensate for warped paper, and a special kicker with the cleats on hinged rider straps which ride the base of the hopper back; in action these raise on the back stroke and lower as the kicker goes forward; again as an aid to feeding warped paper.

Next in line is a printing section which in normal operation serves as a set of feeding rolls. The printing cylinder is equipped with a small aniline ink fountain with a $3^3/_4$-in. face driven by a friction roller running against the cylinder. The purpose of this section is to permit certificates or identification numbers to be put on applicable jobs without the necessity of a separate printing operation. In our operation so far, we have not tried this feature of the press, every time we had such a job we also had more urgent work either plain or with heavy printing.

D. M. Davis, The Hercules Box Co., Div. of Federal Paper Board Co., Inc., Columbus, Ohio.

Following the printing section is an intermediate feed section, which times the blank by stops and also serves as a safety area for jam detection and clearance. Detection is by means of micro switches which stop the machine if two blanks are fed at once or if the blank is fed in crooked.

I might add that the timing and height of rise of the sheet stops is critical and proper adjustment is mandatory for satisfactory operation.

The sheet is fed into the actual die cutting section by chain supported gripper bars which hold the sheet during the cutting and clearing cycles. The actual cutting cycle is accomplished by an arced platten raised and lowered in a progressive fashion by fore and aft cams.

The machine as delivered had no delivery section other than the gripper bar release. I understand a delivery conveyor is now available. We use a right angle counter stacker on short sheets and a combination of a sloped powered conveyor and the counter stacker for longer sheets.

The foregoing, I think, covers the description of the machine we are talking about.

One further thing should be explained. In our operation, die cutting and stripping are separated completely. We run all die cutters as one-man operations, whether Thompson, Cottrell, or S & S, then strip away from the machine. Further, our operators fly their own stock and take completed work to a central area. This should be borne in mind when comparing production rates and footage per hour.

Operation of the press started with very little difficulty and has proceeded satisfactorily. We started and have continued the practice of having the cutting die premounted on the chase plate by personnel in the cutting die room.

We have found three distinct types of setups to be required. First, base setup with no spot sheet prepared, normal time approximately 25 min. We presently run a good 33% of our jobs with no spot sheet at all in the machine. Second, setup with spot sheet preparation involved which normally adds about 15 min., preparation of a spot sheet is very similar to make ready requirements on any other die cut press. Third, setup of repeat jobs with old spot sheet available which is approximately 5 min. above base setup.

Once set up, we have found the machine to be a consistent performer, operating speeds (actual cycle times) of close to machine capacity can be maintained. We have found that on flat board with the corrugations running, the feed direction operating speeds of 55 to 60 cycles per min. are practical.

Jobs with corrugations across the machine will cut operating speeds from 10 to 15% and will miss feed more frequently. We have also found that on jobs with an excessive amount of cutting rule operating speeds must be reduced in order to get blanks out of the machine without falling apart.

The most vexing problems we have found with the machine have been the timing and fore and aft adjustment of the paper adjustment stops, the tendency of the grippers to bite clear through the sheet, particularly on lightweight and bleached liners. There is no adjustment of the closed position of the grippers. We have reached an operating compromise with this problem by filing a flat on the sharp jaw section; however, care must be taken not to go too far. And by far, the most persistent problem has been the tendency of a trimmed sheet to strip itself in the delivery section; as a result, whenever possible, we run the leading edge untrimmed. On the delivery conveyor, we matched as close as we could to the slope of the gripper chains to minimize the twist to the sheet as the trailing edge clears the platten.

On the plus side of the ledger, we feel we have achieved many advantages. Where in the past, die cutting was often a bottleneck, now we have difficulty keeping enough work going through.

We have had excellent results on register and reduced scrap. The scrap reduction comes from the fact that either the sheet goes in right or it does not go in at all. In addition,

sheets with warp that would be very difficult to handle on hand fed presses, feed well in this machine.

We have also accrued an advantage in die life that is rather difficult to explain. For example, we have several repeat orders that have averaged better than 150,000 impressions without re-steeling.

We would recommend to anyone installing this machine, that someone in maintenance be assigned to study and thoroughly understand the stroke timing mechanism on the drive side of the machine. The mechanism is ingenious and properly understood, no great problem, but exact timing is a must. Once in proper time, no tendency to change has been noted.

We would also recommend a safety-lock button be placed inside the discharge section housing, in that the operator must sometimes be in that section out of sight of the control panels.

In summary, we are very pleased with the machine and believe we have achieved higher capacity, better cutting, more accurate registering, less scrap, and longer die life. All with less difficulty than is normally expected in starting new type machinery.

Presented at the 44th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 23–26, 1959.

Printing and Die-Cutting are a Reality on the Swift Gluer-Folder

E. S. SCHNEIDER

As a piece of modern production equipment, the gluer-folder is no longer new to the corrugated box industry. At the 7th Corrugated Containers Conference of TAPPI held in Philadelphia in October, 1957, three excellent papers were given on operating experiences up to that time with gluer-folders then on the market. Even the latest design gluer-folder, having more features than models previously available and which will be discussed in this paper today, is really not new. The fact is that some 50 units have been in operation for a number of years, the prototype of which is roughly 17 years old and still going strong.

What is new, however, is that this particular design of gluer-folder recently has been made available to the corrugating industry as a whole; whereas, heretofore it has been a closely guarded, highly secretive operation, well protected by patents, and in use only in the many plants around the country belonging to one company. The grand-daddy of them all, the name "Quadlok" is familiar to all of us.

It is not intended here to cover again the operating details either reviewed in previous conferences or described in articles which may have been written in various trade publications—time does not permit this. It is sufficient to say that this newest gluer-folder called Glu-Lok is similar to other makes with which you may be familiar, with four major exceptions: (1) the box or blanking section splits apart for faster make-ready; (2) the folding section is more positive; (3) it will print RSC boxes up to four panels in one color; and (4) it will die cut.

BOX OR BLANKING SECTION

While not driven by a gear-head motor, the box or blanking section can nevertheless be opened quite easily with a rachet lever arm that extends out of it on the drive side, once the locking mechanism has been released. This unit splits apart between the two pairs of scoring-slotting shafts located in the front or feed end of the box section, and the one pair of printing or die-cutting shafts located in the back end. The scoring-slotting shafts are 5 in. in diameter, the printing or die-cutting shafts are 6 in., and are one-to-one ratio. The slotting heads, located on the second or middle pair of shafts and the female scoring heads, located on the lower of the first pair of shafts, are yoked together so that all three heads are positioned at the same time and are never out of alignment. The male scoring head, located on the upper of the first pair of shafts, is made ready by itself, usually from the feed end of the unit rather than from inside the opened section. Moving and positioning these heads is simple and positive and is done manually rather than with power—just like most printer-slotters. The advantage, of course, is all with the operator and since he does not have to crawl over or under appurtenances, make-ready time is reduced appreciably.

E. S. Schneider, Vice-President Manufacturing, United Container Co., Philadelphia, Pa.

FOLDING SECTION

Here, as in other gluer-folders, the power to move the blanks from the box or blanking section through the folding section and into the squaring unit is derived from two serrated rubber belts which travel on top of the movable ways. The actual folding of the blanks, however, is not done with another pair of belts as on other models, but is accomplished for the first 90° by folding shoes and guide rods. The folding shoes are set to the two outside score lines of a flat blank, and the two outside panels are bent upward against the folding shoe by adjustable round guide rods. The last 90° of the fold is accomplished by rotating lazy arms which fold the last 90° in a quick action. Folding in this manner produces accurate square folds and helps to eliminate out-of-square or fishtailing. The two top folding shoe assemblies and the two bottom feed-belt assemblies are each adjustable laterally by a separate gear-head motor through a screw. These motors are wired in such a manner that they can be adjusted all at one time—in pairs or individually—allowing for quick and accurate setting by the operator. Before and after the lazy arms, the blanks are held against the moving belts by ball bearing adjustable soft rubber rollers. Slippage or lack of fidelity in flat or folded blanks as they pass through this section certainly is not a problem, providing proper adjustments are made during make-ready.

Blanks having large or deep panels which do not break easily at the score, may be folded upward initially from a horizontal position by using another pair of rotating lazy arms which can be secured to chain-driven shafts situated on the outside face of the movable ways just beyond the glue station. Between this optional pair of lazy arms and the lazy arms which always complete the last 90° of folding, guide rods must be used.

Presquaring of the folded blanks before they enter the squaring unit is accomplished by a pair of tapered-face aluminum rollers driven by V belts and located near the end of the folding section. These rollers are situated one on each side of the movable ways, hence are automatically adjusted with each machine make-ready.

Speaking of machine make-ready, it is interesting to note that the Glu-Lok can be made ready from the center or from the side since the glue pot, slotting, scoring, and printing heads are fully adjustable. Small length and width panels are best set up off to one side—the operator side.

PRINTING

The most important difference between the Glu-Lok and other gluer-folders is its ability to print up to four panels of an RSC box. There are limitations, of course, but so were there with the Model T Ford. Not that there is any similarity between the two machines, but, as the good old Model T was the forerunner of greater things to come in transportation, so might the first gluer-folder—which does a very respectable job of printing—be the harbinger of important advances in the corrugated box industry.

To begin with, printing is accomplished by flexography and blanks are printed on the underside rather than the top side as on printer-slotters. This arrangement, of course, precludes the use of oil or moisture-set inks, neither of which would dry fast enough for the normal running speeds of the machine. Flexographic inks are used which are not only rapid-drying fluid inks but which also can be controlled and applied much more easily in a confined space because an elaborate roller system is not necessary.

Printing, currently, is limited to one color. As many as ten or twelve of the more common colors have been used but only one color at a time can be applied. While flexographic inks are now divided into three groupings based on the solvent used, experience to date is related mainly to the water-base type. Any other solvent would increase the wash-up cost when changing from one color to another and would present safety problems because of the presence of volatile vapors.

The limitation with water-base ink may be the flat print it produces, even though on drying, the ink is no longer water soluble and will withstand washing and soaking tests quite satisfactorily. Gloss can only be achieved with alcohol or hydrocarbon solvent systems, some of the operating disadvantages of which have already been noted.

Printing is done after scoring and slotting, on the underside of the box blank, and not on every order run through the Glu-Lok. It is apparent, therefore, that the printing facilities are not only different from those which are in common use today, but also must be removable. Printing is done with printing units having predetermined widths of printing surface—*not* with one unit which is the full 78-in. width of the machine. At this point there may be some confusion in your minds because of the reference to printing units—plural being indicated and, perhaps, connoting something quite different from what you expected. Well, the present state of the art is limited to printing with two units, one having a printing surface of 12 in. and the other having a printing surface of 18 in. There is every reason to believe that one 40 or 50-in. printing unit is practical, and for that matter, even a wider one than these. But, there are reasons why this has not been accomplished to date, so you will have to be the judge of what is practical in your plant. It may even be that the wide divergence of opinion on this point might result in this feature of the equipment being sized to your specific needs.

A printing unit is comprised of (1) two pairs of split aluminum cylinders, which, when mounted on the separate printing shafts located near the back end of the box section, become the impression cylinder and the plate cylinder; (2) a printing head which includes the ink fountain, the fountain or doctor roller, the form or applicating roller, and the driving gears—all in one integral unit. When printing is to be accomplished, split aluminum cylinders, the length of which corresponds to the printing heads, are bolted together on the printing shafts, which, you will recall, are the third set of shafts expressly for printing or die-cutting. The two cylinders can easily be moved across the shafts to any desired location and there made secure. The bottom or lower cylinder is the plate cylinder and the top or upper one the impression cylinder. Rubber printing dies are stapled to the plate cylinder, which is surfaced with a special covering, the same as on a printer-slotter. The lower shaft, having the plate cylinder secured to it, is adjustable for height or clearance in relation to the upper or impression cylinder.

Beneath and slightly behind the plate cylinder are the printing heads, mounted on carriages which can be moved to any location across the machine by sliding them on the heavy cross bar bolted into the ends of the frame side members. A drive shaft which supplies the power to drive the gear train of the printing head is located within the side frames, parallel with and adjacent to the support bar. When not in use, this drive shaft can be disengaged with a clutch located on the operator side. The carriages on which the printing heads are secured are adjustable in relation to the plate cylinder so that a kiss contact between the form roller of the printing head and the plate cylinder can be effected very easily. When two printing heads are used, one should be left-hand drive and the other right-hand drive so they can be butted together and the space between kept to a minimum for effective two and three-panel printing. The use of additional printing units, depending on the blank size, will provide for printing the other panels.

Now, to get back to the printing heads and to supply you with some of the construction detail that is lacking as of now—the shell of the printing head is an aluminum casting as is the cover. Mounted inside the shell are the fountain and the form rollers, the driving gears of which are located on the outside. The fountain roller is made of 70 Durometer rubber and is fully adjustable to the form roller. The form roller is an anilox roller having a 165-line screen. The two rollers are driven in opposing directions so that the liquid ink flows into a nip between them. The form roller carrying the ink in wells or recesses, transfers the ink to the rubber dies which are mounted on the plate cylinder. The box blanks passing this station are printed by direct contact with the rubber dies—on the underside, that is, as mentioned previously.

Important points that cannot be overlooked are the circulation, viscosity control, and cleanliness control of the rapid-drying fluid inks. Ink is pumped into one side of the fountain and overflows a removable dam on the other side to return by gravity to the ink pump. The nip between the fountain and form rollers is thus always constant, and paper fibers, dust, and other foreign matter are continually removed by the circulation of the ink to and from the pump. The feed line to the fountain is connected to a strainer which traps these particles quite effectively. Viscosity control is very important during a run, though the viscosity of the same color ink may be varied purposely from one job to another. Basically, the thinner the viscosity, as long as the desired end result is achieved, the better. Ink pumps can now be purchased with a viscosity control attachment so that the desired viscosity can be held within plus or minus one-half second on a no. 3 Zahn cup.

So as not to slow down make-ready time, at least two of each size printing heads must be on hand so that as colors change from one order to the next, a clean printing head can be installed and the used one washed up away from the machine. This same thing applies to the pump and the plastic tubing used to convey the ink to and from the printing heads.

Male and female dies should be employed for die cutting and since this type of die is more costly than steel-rule dies, it means that fairly good volume must be indicated to justify the additional expense. The dies are mounted on holders which in turn are mounted on heads, each with a T-slot running circumferentially. In this manner, the punches and dies can be located wherever necessary.

Since the same equipment is not used for printing and for die cutting, it can be seen that both operations can be done at the same time on the extra-heavy shafts designed for this purpose, providing the printing and die cutting are not in the same panel.

SUMMARY

The fact that blanks right off the corrugator can now be transported directly to the finishing department where they can be converted into the finished product on one machine, is good news for the cost-minded corrugated box maker. And, who isn't cost-minded these days? Experience with the first model of this new equipment is limited because this unit has been in operation at the United Container Co. only since mid-September. However, what it will accomplish

has previously been demonstrated, and here is some information that may be of interest.

1. Average make-ready time: 18 min. on a 31 by 78-in. machine. This time includes a fair number of orders that were printed in the manner described above and covers a substantial period of time.

2. Average number of pieces per hour: 8700. This figure also covers an extended period of time and includes jobs that were printed on this equipment.

3. Average square feet produced per hour: 50,800. The same comment just made applies here.

The foregoing is not fiction or fantasy but actual fact. At United Container Co. the make-ready time and production averages are nowhere near these times but who can expect personnel with a few months' experience on the pilot model of a new piece of equipment to match the speed and skill of personnel with years of experience? Steady improvement is being made and no one will be satisfied, including the people on the machine, until these averages are achieved. The Glu-Lok does have the wherewithal to do the same job as the "Quadlok" and, in fact, has a top speed far beyond the capabilities of personnel working without further mechanical assistance.

There seems to be little doubt that one of the machines of the future, often referred to when a group of production and/or development men get together to mull over ideas, is here now.

Presented at the 44th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 23–26, 1959.

Operating Experiences with the 42 by 62 Bobst

BASIL M. PARSONS

This report is made in composite form from information received from the Bobst distributors and from various plants throughout the United States where the 42 by 62 Bobst has been installed and where they have been performing for at least 6 months to 1 year. All information has been voluntarily supplied by Bobst users and the Bobst distributors have supplied a full description of the press.

The 42 by 62 Bobst is a fully automatic cutting and creasing press for the die cutting and scoring of both corrugated and solid fiber. It is made in three models: (1) with automatic feed, roll-off delivery and no stripping stations; (2) with automatic feed, in-line delivery and one automatic stripping station; (3) with automatic feed, in-line delivery and two automatic stripping stations.

With no automatic stripping stations and with roll-off delivery, the speed is up to 4500 sheets per hour and sheets are counted and jogged in piles of 10 or more on the roll-off delivery where they are stacked and stripped away from the press.

With one automatic stripping station and with in-line delivery, the speed is up to 4000 impressions per hr. Interior waste and side trim are automatically removed with the single stripping station and the blanks are counted in piles of 10 or more and dropped onto an in-line conveyor and carried to the rear of the press where they are stacked and front trim later removed away from the press.

With two automatic stripping stations, and with in-line delivery, the speed is up to 3600 sheets per hr. Interior waste and side trim are automatically removed on the first stripping station and front trim or leading edge is automatically removed in the second stripping station. Completely stripped blanks are carried to the rear of the press on the in-line conveyor after having been automatically counted in piles of ten or more and dropped to the conveyor. In the meantime, the front trim or leading edge is carried out from the side of the press on a cross conveyor.

The strippers work on the "male" and "female" principle with an upper male stripping chase of steel or plywood and a lower female made of plywood cut out on a jig saw. Complete register is attained in this simple process.

The 42 by 62 Bobst of either style has a cutting load capacity of 275 tons, far greater than the average job requires. All 42 by 62 machines are designed to take either standard 0.937 or $1^1/_8$-in. cutting rules.

R. C. Dyer of Container Corp. of Oakland, Calif., recently reported that they were operating their 42 by 62 Bobst with a two-man crew and were averaging between 2000 and 2500 impressions per hour. This average was arrived at by taking time for cutting make ready and time for setting up strippers. On repeat orders, the setup time is reduced about two thirds. He further reported that when machine is used for plain die cutting and stripping stations are by-passed, the setup time is no longer than that required for a hand-fed platen cutting and creasing press. An earlier report from Container at Oakland, Calif., stated they were already saving $4.60 per thousand sheets over previous methods but expected to greatly improve this with more experience. Mr. Dyer concluded his report by stating, "We are well pleased with the over-all operation and quality of work which we are getting from the Bobst die-cutting press."

W. A. Kinney, plant manager of the Flintkote Co., San Leandro, Calif., who have only had their 42 by 62 Bobst for a short time, reports as follows:

"Average time for making ready on cutting and creasing only takes approximately one-half hour. The average time for setting up the first automatic stripper is approximately one hour. The second stripper requires only approximately 5 min. The average production by sheets per hour is approximately 1500 and the best day we've had was 1750 per hr. This, of course, included the time of stops for various reasons such as clean up time, coffee breaks, etc.

"It is expected that the coming year will show considerable improvement in our production per hour. The fact that the finished, stripped die-cut blanks come out of the machine without the laborious effort otherwise accompanying the stripping operation is a tremendous help in meeting schedules. With these things in mind, we are very happy with the machine."

Gaylord Container Corp. Div. of Crown Zellerbach, at Tampa, Fla., who have a 42 by 62 Bobst with one stripper, report through their plant superintendent, K. A. Oliven, as follows:

"The average time for making ready for cutting and creasing on the cutting platen is 30 min. The average time for setting up the automatic stripper is 24 min. and the general average of the number of sheets per hour on normal jobs is between 2200 and 2500 sheets. In order to speed up our set up operations, we slotted holes in back Hopper guides so bolts do not have to be removed. We also make our die boards full size of chase to eliminate the time consuming special locking device for smaller dies. We like this equipment very much and the automatic stripping feature has given us a considerable cost reduction in this operation and we also have benefited a lot by the increased output per hour in comparison to other die cutting equipment we have been using."

Complete reports have not as yet been supplied by Inland Container Corp. who have a 42 by 62 Bobst with two strippers at Middletown, Ohio, and another similar machine in their plant at Macon, Ga. Inland advises they are working out methods and time studies. Verbally, Inland has advised about producing up to 3500 sheets per hr. at Middletown, including stripping, and they ran a "chick" box as well as "chick" box partitions at Macon, Ga., at a speed of from 3000 to 3200 per hr.

Basil M. Parsons, Vice-President-Sales, Thomson-National Press Co., Inc., Franklin, Mass.

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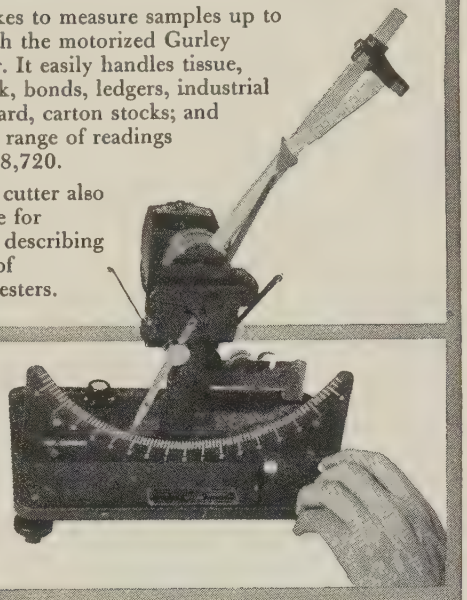

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John W. Heist, plant engineer for International Paper Co., Georgetown, S. C., reports that they have not as yet operated long enough to get the full benefits from their 42 by 62 Bobst with two automatic strippers. So far the average time for preparing the cutting makeready is 30 min. and the average time for a complete two-stripper setup is $1^1/_2$ hrs.

G. Boughton, Superintendent of the Robert Gair Div. of Continental Can Co., Syracuse, N. Y., who has a 42 by 62 Bobst with one automatic stripper, reports complete satisfaction with the machine. Their experience is mostly based on short runs but they operate up to 3200 sheets per hr. on their longest runs. Ninety per cent of their work represents repeat orders which permits of fast changeovers from one job to another.

Joseph Schiffenhaus of Schiffenhaus Brothers, Newark, N. J., has the first 42 by 62 Bobst in the United States which is being changed over to have all of the latest features. In the meantime, they report jobs running at 2000 per hr. with stripping and at 3000 per hr. without stripping.

Container Corp. of America with three 42 by 62 Bobst machines installed and two additional machines to be installed shortly, are planning to use some of them for solid fiber work. One job consisting of an 80-pt. solid fiber beer case ran on a 42 by 62 Bobst for Container Corp. at a speed of 3500 cases per hr.

The first 42 by 62 Bobst without strippers was installed about one month ago in the plant of A & P Corrugated Box Co., Gardner, Mass. The first two jobs on this machine ran off at a speed of 4000 to 4500 sheets per hr. with makeready time equal to or somewhat faster than on a hand-fed platen cutting and creasing press. This machine is designed for high speed without stripping and for fast changeovers from one job to another.

Presented at the 44th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 23–26, 1959.

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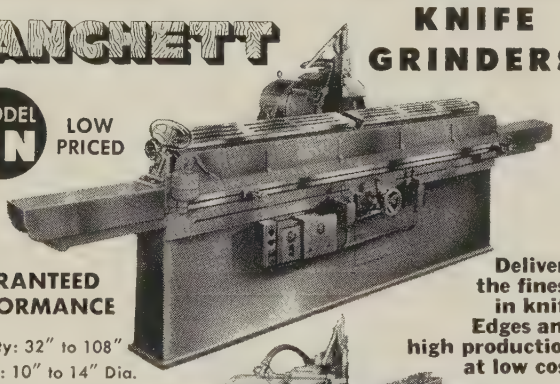

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Paper Manufacture Under Near Sterile Conditions

NORMAN ALPER

Chlorine dioxide for many years has been used in the paper and other industries as a bleaching agent and by water works for disinfection and for taste and odor reduction. In these applications, large volumes of chlorine dioxide are consumed and it is economically practical to manufacture it at the point of use and utilize it immediately. Obviously, the necessity of generating this chemical at point of use limited its applications. An additional deterrent to wider use of chlorine dioxide are several undesirable characteristics. It is unstable and concentrated chlorine dioxide gas is explosive. Its manufacture requires the installation of certain safe guards and observing precautions usually practiced in the handling of toxic and acid chemicals. It has a disagreeable odor, is toxic and irritating (*1*). Also apparent is the potential usefulness of chlorine dioxide's excellent bactericidal, sporicidal, and odor control properties, if it were available in a form free from the above objectionable features. And if it could be supplied in containers, smaller scale applications would become feasible in situations which would not warrant the capital investment required for a generator.

A year ago, a stabilized chlorine dioxide solution was made available. A paper describing its properties, behavior and results of laboratory tests was presented at the 1958 Annual meeting of TAPPI. During the past year, considerable progress has been made in the application of stabilized chlorine dioxide as a microbicidal agent and also in improving certain desirable characteristics of the stabilized chlorine dioxide complex.

CHARACTERISTICS OF STABILIZED CHLORINE DIOXIDE

Stabilized chlorine dioxide solution has a pH of 8.0 to 8.5 and a specific gravity of 1.063. It is classified by the Bureau of Explosives of the Association of American Railroads as a corrosive liquid N. O. S. under I. C. C. regulations and should be handled in transportation like sodium hypochlorite solutions.

Lowering the pH results in the release of chlorine dioxide from the complex. The rate of release increases with lower pH levels. Unlike chlorine, the bactericidal properties of chlorine dioxide are not materially affected by pH values between 6.0 and 10.0 (*2*). It has a lower oxidation potential than hypochlorite and, therefore, has a more specific action on lignin, leaving cellulose almost unattacked (*3*). A comparison of the characteristics of aqueous solutions of stabilized chlorine dioxide and of gaseous chlorine dioxide in aqueous solution is given in Table I.

During the past year several improvements have been made on the basic product. Perhaps the most important is the complete elimination of any possible trace of boron. Speculation on the potential presence of residual boron had been a source of uncertainty among some toxicologists for no acceptable concentration had yet been determined. The stability of the stabilized chlorine dioxide product has been improved with current production providing shelf-life in excess of six months. At the same time, the concentration of the solution has been increased so that the 4.0% product is now being produced in excess of 4.5% and up to 5.0%.

Norman Alper, Director of Industrial Sales and Market Development, Chemical Research Laboratories of America, Inc., Lafayette, R. I.

MICROBICIDAL PROPERTIES

The bactericidal and sporicidal properties of chlorine dioxide in the treatment of water has been the subject of a number of investigations (*2, 4, 5*). These studies disclosed that chlorine dioxide was equal to or better than chlorine under various conditions of use. Although the greater part of application experience with stabilized chlorine dioxide has been in paper mills, limited investigations have shown that in the medical field, stabilized chlorine dioxide medications have been very effective in the treatment of certain skin conditions.

Table I. Bactericidal Effects of Stabilized Chlorine Dioxide

Sample		
1	Untreated	60,000
	Stabilized chlorine dioxide, 0.6 p.p.m.	3
2	Untreated	17,500
	Stabilized chlorine dioxide, 0.8 p.p.m.	11,600
	1.2 p.p.m.	70

Preliminary studies also indicate that stabilized chlorine dioxide may serve as a very effective bactericide in tannery operations. The variety and number of microorganisms, encountered in the soaking of skins prior to tanning, is much greater than is met with in paper making. During the soaking process, bacterial decomposition of protein materials normally results in the occurrence of the very disagreeable smelling degradation products, indol and skatol. Laboratory tests, conducted under conditions more severe than in an industrial tannery, showed that stabilized chlorine dioxide effectively suppressed the production of these odors.

SLIME IN PAPER MILLS

Microorganisms of several types are the cause of slimes, a major problem in most paper mills, and are also an important source of objectionable tastes and odors in paper products. The effect of slime accumulations on production and quality of paper is too well known to require any further elaboration. However, the cost of these losses is seldom fully realized by many mills so that the establishment and maintenance of an effective slime control program is often neglected. The benefits obtained from the use of a good slime control agent generally enables it to more than pay for itself.

TASTES AND ODORS

Undesirable tastes and odors may result from other sources besides microorganisms. But, whatever the cause, their presence in paper products used in packaging, especially of foods, is objectionable. Mills have produced materials which met high packaging specification requirements and then had shipments rejected only because of off-flavors or odors. A frequent cause of objectionable tastes and odors is the chlorination of water which contains phenols, resulting in the formation of the highly disagreeable chlorphenols. This does not occur when chlorine dioxide is used.

TESTS OF TOXICANT PROPERTIES

Laboratory tests of the toxicant properties of stabilized chlorine dioxide were made on samples of water from paper mills, preliminary to mill trial tests. In these experiments, the water samples were treated with various concentrations of stabilized chlorine dioxide and, after a 2-hr. contact time, plated on a tryptone glucose agar medium and incubated at 35 °C. for 48 hr. Conducting the tests in this manner is more informative because it permits determinations of the influence of the stock on the behavior of the toxicant. Since toxicants which attack microorganisms by their oxidizing action also react with other organic materials, it is necessary to perform the tests with these materials present. The results of these tests are shown in Table I.

The laboratory tests indicated that the chlorine dioxide requirements to accomplish control of microorganisms varies with water from different sources. This is not unusual since considerable variation may exist in white water composition. Organic matter content, type and condition of bacteria population influence chlorine dioxide demand.

MILL TRIAL

Laboratory evaluations of germicides are conducted under carefully controlled conditions with variables kept to the minimum. The true measure of a paper plant bactericidal agent can only be determined by mill trials whereby the effect of operating conditions and variables may be observed. A plant trial furnishes additional information besides bactericidal effectiveness. Answers to many questions can be obtained at this stage. Among the important ones are the following: Can equipment be installed without difficulty? Will disagreeable odors be produced? Will it be irritating or toxic to mill operators? Does it corrode or otherwise attack mill equipment? How will paper quality be affected?

Table II. Comparison of Characteristics of Stabilized Chlorine Dioxide and Gaseous Chlorine Dioxide in Aqueous Solution

	Stabilized chlorine dioxide	*Gaseous chlorine dioxide in aqueous solution*
Appearance	Colorless to light yellow liquid	Bright yellow liquid
Odor	None to slight odor of ozone in all concentrations	Disagreeable, irritating odor, evident in concentrations of 14–17 p.p.m.
Concentration of chlorine dioxide	Standard product—45 g.p.l. or 45,000 p.p.m. (higher strengths are possible)	Maximum—2.9 g.p. or 2900 p.p.m
Corrosive action	Concentrated solution is corrosive to steel. In dilutions recommended for use in pulp and paper mill, it is not corrosive to steel, copper, bronze, or other paper mill metals	Extremely corrosive
Stability in storage	Excellent—39° to 120°F.	Decomposes rapidly
Chlorine content	0.5–0.1%	Up to 45%—depending upon method of manufacturing chlorine dioxide

Slime Control Agent in Paper Mill

The first extensive evaluation of stabilized chlorine dioxide as a chemical treatment to control slime was made in a mill making various types of bleached and colored paper. The machine used for the tests had been operated for several years without chemical treatment. The fresh water supply was chlorinated but this had insignificant influence on slime deposits or slime microorganisms in the machine, because most of its water requirements were met by recirculating white water. At the time treatment was initiated, heavy slime growths had accumulated throughout the system and an increase in slime spots and breaks had been reported.

Stabilized Chlorine Dioxide Supply System

Installation of the stabilized chlorine dioxide supply system was quite simple. Stabilized chlorine dioxide is shipped in polyethylene lined drums which are readily placed close to point of application. Since the concentrated solution is fed at a very low rate, a compact, reliable metering pump, placed on top of the drum, provides the required flow to the machine through lightweight, flexible, plastic tubing which is quickly and easily installed. This arrangement permits changes in point of application with very little trouble, and makes accessible elevated sections of the machine.

Application Rates

Treatment of the system was begun with slug doses at the headbox fan pump, at the saveall and at a back-water tank; and at about the same time continuous feeding was started at the fan pump. Additional slug doses were added at the fan pump twice, late at night. After the first day, stabilized chlorine dioxide was added to the system only by continuous feed at the headbox fan pump. Tests for residual chlorine dioxide made at various parts of the system, 48 hr. after treatment was begun, revealed residuals ranging from 0.1 p.p.m. at the jordan headbox to 0.6 p.p.m. at the machine head box.

Results of Treatment

In less than 3 days of treatment with stabilized chlorine dioxide, its effectiveness as a means of slime control was dramatically displayed. Previous to the treatment, the top speed of the machine had been 200 f.p.m., but shortly after treatment was begun, it was possible to increase machine speed to 210 f.p.m. Not only was production increased but the quality of the paper was substantially improved. A radical reduction of slime spots was noticed and breaks, attributive to slime, no longer occurred.

During the wash-up it was noted that deposits of filler materials in the pipes, which formerly could only be partially removed with difficulty, were now washed off readily. The wash water draining from the machine was now relatively clear whereas formerly it came out dirty. In general, it was found that after treatment with stabilized chlorine dioxide, cleaning of the machine was much easier because of the clean condition of the wires, felts, and screens, and the absence of slime deposits. And what is more significant is that this machine has been maintained in this condition for many months merely by adding to the water about 1 gal. of stabilized chlorine dioxide during each 24 hr. of operation.

Pink Slime

Pink slime is an annoying problem in many paper mills and has been found difficult to eliminate since it does not always respond to slime control treatments conventionally used. It is believed that the extreme resistance in the mill of some types of pink slime may be due to the inability of the chemical treatment to penetrate through the slime mass (*6*).

Stabilized chlorine dioxide is especially effective against pink slime because of its ability to disintegrate the slime mass and expose the organisms to the bactericidal action of the chlorine dioxide. Our experience in paper mills where machines have been infected with pink slime which did not respond to treatment with various types of slime control agents has shown that stabilized chlorine dioxide, at the same dosage levels used for general slime control, was effective in destroy-

ing the pink slime and has prevented its recurrence during the many months since treatment was initiated.

Experience At Other Mills

The performance obtained at this mill has been repeated many times. Although stabilized chlorine dioxide was found to be a very beneficial toxicant in machines making paper from bleached chemical pulp, we were uncertain about its suitability in systems where groundwood or unbleached chemical pulps were used. Chlorine dioxide reacting with the relatively large quantity of lignin present in these systems would be expected to form colored compounds resulting in a lower paper brightness. The initial application to a machine using a groundwood stock resulted in an appreciable loss in brightness. However, because of the excellent experience this mill had obtained with stabilized chlorine dioxide in machines using bleached pulp, it was decided to experiment with reduced dosages of chlorine dioxide. Adequate control of slime has been obtained on this machine with a low level feed of stabilized chlorine dioxide without significant reduction in brightness. It has been tried in newsprint and in boxboard mills and the reports show that, in general, an improvement in slime control has been achieved. The relationship between chlorine dioxide concentration and brightness of various types of paper pulp is under laboratory investigation at the present time.

Some mill operators who have used different types of oxidizing agents which produced adverse effects on machine metals or felts or on wet strength papers have been hesitant about trying stabilized chlorine dioxide. Our present experience with stabilized chlorine dioxide in various mills indicates that in use dilutions: (1) it does not promote corrosion of the metals normally found in paper machines, (2) it does not weaken felts, (3) it does not react with wet strength resins nor modify the physical characteristics of wet-strength paper products.

CONCLUSIONS

During the year that has elapsed since the last TAPPI Annual Meeting, stabilized chlorine dioxide has been successfully used in various mills for control of slime. It has been found to be effective against slime microorganisms and also in breaking down slime deposits so that they could be readily flushed away. These results were obtained without creating annoying or hazardous working conditions in the mill, with no adverse conditions developed on the machine itself, and with no toxic residues and no objectionable odors in the paper product and without contributing to stream pollution.

Stabilized chlorine dioxide merits serious consideration, particularly by mills producing food packaging materials. Because it is practically odorless, reduces tastes and odors present in the stock, and leaves no toxic residues in the paper, stabilized chlorine dioxide is a valuable aid in making a product that meets stringent packaging requirements.

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Cylinder Board Formation, Measurable or Predictable?

THOMAS E. BROOKOVER

This paper resembles an Uncle Remus story: the culprit (myself) is entangled in a trap of his own making, and the conclusion is developed through relating generalities. The use of generalities certainly must be a novel situation in the cylinder board industry in which the effects of all operational variables have been analyzed and cataloged so precisely that very few technical problems remain.

A group of men, representing a significant segment of the cylinder board industry, was conducting a full scale evaluation program of a commercial forming device. Sample runs of normal filler and white liner stocks produced single ply sheets at speeds up to 500 f.p.m. As the trial runs progressed reports on them described the formation as "better than," "poorer than," and the inevitable "50% better than," etc. Industry representatives disagreed among themselves regarding the quality of a given sample's formation. Some began to question whether all who were passing judgment on the test sheets actually knew or could visualize the "formation quality" of plies in commercial sheets from their own machines.

Samples of commercial sheets from several of the participating companies were obtained, and the individual plies of 4 by 8 in. samples were carefully separated. Ply samples were cataloged according to grade, weight, and machine speed. Typical samples were photographed by transmitted light; the photograph prints had a 1:1 area ratio with the samples. Photographs of test sheet samples were prepared for comparison.

A representative group from the industry met to examine the photographs. The group agreed the photographs did tell the exact story of the samples' visual formation quality. With the coded pictures mounted on large frames for examination, several interesting things happened:

1. Excellent formation was scarce in the display and easily determined.
2. Very poor formation was less scarce and easily determined.
3. Most of the examples displayed were similar to each other and certainly not "good."
4. It was recognized that formation of samples taken from the test forming device was not "bad" as many had judged but was actually better than that of many of the industry samples.
5. One industry representative selected one group of pictures and claimed "such stuff wouldn't be acceptable to his company's customers." The pictures represented samples of that company's "commercial sheets."

It was obvious from the foregoing that Socrates' admonition to "Know thyself" was either unknown or ignored.

This, then, was the background for the interest some of us developed in having a simple and rapid method of evaluating single ply formation on multicylinder machines. Further consideration has led us to believe that the eyes of research in this case were larger than the stomach of practicality.

When asked to participate in a discussion of this subject in this TAPPI program, I reviewed TAPPI Technical Papers from 1939 to 1957 inclusive to gain the benefit of the background of others' efforts and opinions. Following are some observations drawn from that review.

"Formation" seems to be generally accepted as "a term relating to the distribution of fibers in a sheet of paper as judged by transmitted light." Further, we all know effort has been continuous to improve this distribution of fibers in stock and, thereby, to provide "good" formation. I am sure

Thomas E. Brookover, General Manager, Technical Services, Downingtown Paper Co., Downingtown, Pa.

all would agree that excellent "dispersion" of the fibers *during* formation provides excellent fiber distribution and, therefore, excellent formation.

Methods of evaluating single ply formation, noted in TAPPI during these years, included:

1. A Thwing Albert formation tester, based on the variation or uniformity of a light beam transmitted through a moving sample.
2. A method, proposed by James d'A. Clark, in which excess chalk is scraped from a known sample area with a straight edge and that remaining is titrated with standard acid. Formation was related to one type of smoothness in this case.
3. Photography by transmitted light.

For the most part, comparative generalizations have been used in TAPPI down through the years to describe formation. A list of descriptive terms includes: "superior," "good," "poor," "mottled," "ultimate," "perfect," "reasonable," "unreasonable," "uniform," "nonuniform," and finally, one rugged individual made it complete by using "disgraceful."

One party used fourdrinier formation as a standard; elsewhere fourdrinier formation, *per se,* was quite unacceptable. While appreciable formation advantages have been claimed for uniflow over counterflow vats, one man was brave enough to state his own conviction that there was little basic difference in the formation results to be obtained from the two types of vats (I believe he would reserve the right to establish limits on several operational variables to demonstrate the validity of his contention).

There is reference in the TAPPI papers to the "futility" of attempting to improve cylinder formation (under the operational conditions some of us impose, probably), but the reference recognized the necessity of further study and experimentation.

Although there has been little reference to statistical formation evaluation, we find varying opinions regarding the basis or source for whatever formation (even up to "ideal" formation) we do realize: in one reference 90% of "ideal" formation was felt attributable to machine operation while in another reference 75% of "ideal" formation was assigned to proper stock processing. I believe these widespread opinions were expressed in successive years at the annual TAPPI meeting.

Such has been the history of the industry's judgment of formation in the past nearly two decades.

Obviously, formation evaluation on a multicylindered machine is much more difficult than on a single-ply machine. If overall sheet characteristics are important, and if sheet characteristics are related to formation, the formation of more than one ply and/or combinations of them may seriously affect the end result. If formation evaluation were to be a production tool, it would have to apply to all plies: in fact it would have to apply across or scan the full width of each ply, because formation has been known to vary across the web at a given instant and from time to time. To evaluate formation dependably and continually in multiply work seems impractical: the very wet webs are discrete on a wire for a fraction of a second only and, after contacting another surface may be observed from one side only for approximately a second. Photo-television methods may be developed but seem far fetched at this time.

In the preceding paragraph I said measurement should apply to the full width of all plies if it is to be done at all. This is a personal conviction related to the problem of satisfactory representative sampling. Let's acknowledge with regret that our industry has been guilty of accepting test results from a minute section of product as being indicative of major sections of the whole when so-called practicality limits the ability to sample representatively. The desire to assign a representative value to a variable must be harnessed to realism and validity.

We have used careful ply separations of samples of finished sheets to study formation. Diamond Gardner has developed a method of sampling an individual ply by intentionally destroying ply bond in the desired sample area. The Thwing Albert instrument could be used on samples so obtained. These seem to be laborious methods. Such methods, as well as that utilizing radio active tracers, are case study tools and are not continuous production controls in my opinion.

Reverting to the assumption that good stock dispersion produces good formation, high speed photography, stroboscopic examination, pitot tubes and current meters have been suggested for analyzing flows on which formation *may* depend. Unfortunately, there is strong evidence that flows which may be properly dispersed before reaching the making board become decidedly improper in conventional vat circles.

In addition to the discouraging aspects of continuously measuring formation by uniform standards, another disturbing doubt enters the picture. If machine operators had a satisfactory formation indicator or recorder, could they use the information rapidly enough to do anything about it today: in the case of one ply varying across the width of the ply or in the case of variation between plies furnished with the same stock? It seems to me there are less complicated cases of variations of other properties that are not always dependably controlled on production machines today—or are there no difficulties today with blows, moisture, weight, and caliper?

Another disturbing question arose in considering the background of this broadening subject of formation measurement. What is formation's role in multicylindered sheets, how important is it? Referring again to the many years of TAPPI papers, we find general agreement of opinion in this respect. In one case formation was claimed to have more direct bearing on the product, and, therefore, the profits, than any other step in the papermaking process: although this refers to the act of formation specifically, it must also relate to the finished result. Another party held that product performance difficulties resulted from poor formation as well as weight variation (formation, of course, is related to localized weight distribution). Good formation has been associated with smoothness, good printing, good coating stock and sheet strength. Conversely, there was also recognition that good smoothness is possible without good formation; mottled printing may result in this case.

Yet, one wonders. Remember the industry representatives who were surprised when faced with the actual generally poor formation characteristics of the commercially acceptable sheets (quality sheets at that in several cases)? Similar industry representatives have dwelt on the value of good formation in paper and paper board converting. How good is this "good" formation that is deemed valuable? In spite of many opinions to the contrary there is strong evidence that excellent converting and printing results have been and are being obtained on multicylinder boards, the bulk of which is made up of plies whose formation is neither "superior" or "very good" nor "very bad" or "disgraceful." These converting and printing processes must have tolerated or compensated for the unlabelled wide ranges of "formation" normally found in our industry.

The case for uniformly measuring formation has lost strength in my opinion and by my admission. However, this in no way means there is a case for "very poor" or "disgraceful" or even today's normal formation. The demands of converting and printing, if not the operational demands of our multicylindered industry, will narrow the quality range and raise the average requirements of the "formation quality." I believe the alternative to "uniform measurement" and "control" of this property is "dependable and predictable" formation; this would practically eliminate the need for measurements.

Gough, in 1943, stressed the need for a carefully designed and arranged approach section to suit *exact* operating con-

ditions. Others have also dwelt on the same general theme. The word *exact* in the statement is probably one of the keys to the formation problem: if hydraulics were fixed *exactly* in a given installation, the chances of approaching at least "good" formation would probably be enhanced, and "dependable and predictable" formation on a forming device would be closer to realization.

Recent developments in the industry (e.g., various vacuum former arrangements and continued approach system investigations) and commercial production by some of the developments indicate "dependable and predictable" formation may be much nearer at hand than we felt possible five years ago.

With "dependable and predictable" formation the effect of intentional system changes could be evaluated more readily. Converting and printing processes would be related to a narrower range and probably a higher level of formation quality.

And so, for this story's conclusion, I, for one, gladly replace my interest in uniform measurement of formation with this "dependable and predictable" formation whose role could be readily evaluated in our industry and those industries associated with it. On this, at least I think we can agree.

Presented at the 44th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 23–26, 1959.

Upgrading of Molded Pulp Products Through the Use of Synthetic Resins

BAYARD L. CARLSON and FREDERIC HOROWITZ

During the last ten years many new applications for pulp and paper products have been developed through the cooperative efforts of the paper industry and synthetic resin manufacturers.

Synthetic resins can be applied to paper by internal application (beater addition) or by surface treatment (tub sizing or saturation).

Beater addition is the simplest method of incorporating resinous materials in paper, inasmuch as no special equipment is required. The expression, "beater addition" should not be taken literally since the resin may be added at other locations than the beater, such as the hydrapulper, stock chest, fan pump, jordan outlet, consistency regulator, or headbox.

SYNTHETIC RESIN DEVELOPMENT

The best known types of synthetic resins used for beater addition are urea-formaldehyde and melamine-formaldehyde resins, generally used in the paper industry for the improvement of wet-strength properties. The use of phenol-formaldehyde resins in the paper manufacturing process has remained very restricted due to the fact that ordinary phenolics, when applied under conditions similar to those recommended for urea and melamine wet-strength resins, will produce only very minor strength improvements. The reasons for this behavior have been mainly one or several of the following: low retention of the resin on the cellulose fibers, poor distribution of the resin in the paper, and incomplete cure of the resin by the heat available during the drying operation on conventional papermaking equipment.

Recently several excellent theoretical studies on the use of radiant heat in curing phenolic resin-treated papers have been made and reported in *Tappi* (*1*, *2*).

It was shown in these studies that phenol-formaldehyde resins can be cured with radiant heat without degradation of the cellulose and that the principal difference of phenolic resins and commercial nitrogenous wet-strength resins is in the ease of curing. Comparable wet-strength improvements were obtained in phenolic resin-treated papers when higher temperature curing was employed and at the same time less degradation due to overheating was exhibited. This was achieved by exposure to infrared heating units.

Phenolic resins are prepared by reacting phenols and aldehydes (mainly formaldehyde) in the presence of catalysts at elevated temperatures. Variations in the ratio of reactants, catalysts, and temperature alter the properties of resins such that a wide variety of materials may be prepared. These resins vary from water-soluble to water-insoluble and from liquid to solid.

An ideal phenol-formaldehyde resin applicable in the pulp and paper industry should meet the following requirements: (1) *water solubility* to a certain degree to permit addition at the beater or at any other point in the system; (2) available in *liquid form* to give uniform dispersion in the pulp or fiber slurry in a short period of time; (3) be a *condensation polymer of proper molecular weight* to produce nearly quantitative retention on the cellulose fibers when the resin-fiber slurry is treated with a suitable precipitating agent; (4) be a *polymer of very uniform molecular distribution* since low molecular weight fractions reduce appreciably the retention and high molecular weight fractions precipitate usually in rather large flocs that affect the drainage rate of the pulp slurry.

A few years ago, a new technique of making phenol-formaldehyde reaction products was developed (*3*).

The concept of this process is to prolong or expand the condensation reaction of phenol and formaldehyde in the water-soluble phase with a resulting improvement of the final product as to advancement and reactivity. In the prior art, it has always been considered that the end of the soluble stage, just before the final act of setting into the insoluble-infusible stage, has been reached when the viscosity curve began to rise sharply. In the new process unique catalysis conditions have permitted preparation of a condensation polymer of extreme uniformity and high molecular weight. The polymer thus formed has a relatively low viscosity to permit easy handling in liquid state and excellent water solubility.

One of the several commercial phenolic resins manufactured by this new and different process (AMRES 1420) was found to be especially suited for use in the pulp and paper industry. This material has been mill tested extensively and is being used in a wide range of paper grades, (linerboard, boxboard, bookbinder board, medium density overlay paper, etc.) manufactured on conventional paper machines. But its most striking and successful application was found in the pulp molding industry.

INDUSTRIAL APPLICATION

The central region of the State of Washington is widely known for its excellent fruit crops, with the apple growing industry being the major contributor. There it was recognized many years ago that by the simple process of selecting quality fruit and establishing an identity or brand, quality can be sold at a premium (*4*).

Apple retailers and consumers have continually demanded apples without bruises, cuts, and stem punctures. Handling and packaging techniques have been continually improved, leading to the present semimanual mechanical tray packer developed by the Fruit Industries Research Foundation at Yakima, Wash. This mechanical tray packing method permits packing at the rate of 60 boxes or more per hour.

Three years ago, tray packs represented only 10% of the Washington State crop, in 1957 about 25% were tray packed, the 1958 estimate being 33%, and it is predicted that 5 years from now over 90% of the pack will be in trays and in corrugated boxes.

Bayard L. Carlson, Special Products Department, American-Marietta Co., Seattle, Wash., and Frederic Horowitz, Technical Service Manager, American-Marietta Co., Newark, Ohio.

EXPERIMENTAL

Laboratory Testing

Development work with the principal West Coast supplier of "Friday Pack" molded pulp trays, the Pacific Pulp Molding Co. of Wenatchee, Wash., started in the latter part of 1955. This company had requested assistance to improve their products to meet the higher requirements of automated fruit packing.

Initially, laboratory handsheets were formed on an $8^1/_2$ by $8^1/_2$ in. square sheet mold using the Standard TAPPI procedure T 205 m-53. The furnish consisted of the following:

Pulp: Waste news repulped in a $1^1/_2$-lb. Valley beater. Stock at 1.5% consistency and Canadian Standard freeness of 335 ml. Stock pH adjusted to 8.5 with sodium hydroxide prior to addition of chemicals.
Basis weight: 70 lb. per 1000 sq. ft.
Size: 3% "N" rosin size based on oven-dry fiber.
Resin: (a) None (control). (b) 2% AMRES 1420 (resin solids on dry fiber). (c) 5% AMRES 1420 (resin solids on dry fiber).
Catalyst: 3% dry alum to stock pH of 4.5–5.0.

The handsheets were cured for 5 min. at 300°F. in a convection-type oven and tested for dry tensile and Hinde-Dauch ring crush stiffness. Test results shown in Table I.

Table I. Handsheet Test Results

	Dry tensile, lb. per in.	*H & D ring crush stiffness, lb.*
Control (no resin)	8.47	20
2% resin	17.74	41
5% resin	24.61	56

Considerable improvements in dry tensile strength and ring crust stiffness were obtained. Mill trial at the 1 and 2% resin level was suggested, with the resin usage held to these lower figures because it was felt that this would produce adequate improvement of the product.

The slight effect of resin addition on freeness was not considered great enough to be noticeable on production equipment.

Mill Testing

These promising laboratory results led to an initial mill trial at Pacific Pulp Molding Co. The phenolic resin, 2% resin solids based on dry fiber, was added to the regular beater charge: 425 lb. waste news, 11 lb. size, 13 lb. alum, and $1^1/_2$ lb. methylene violet dye. The resin treated stock was pumped into stock chests, from where it passed through a jordan refiner and into the headbox of a production molding machine.

Samples were taken from this machine prior to trial run, during resin test and several hours after completion of test run. During this test, resin cure was accomplished in the gas-fired drying tunnels at temperatures ranging from 350 to 425°F.

Tests were made by cutting strips, $^1/_2$ in. wide and 3 in. long, from the edges of the trays. The dry and wet tensile strengths were tested according to standard TAPPI procedure as summarized in Table II.

Table II. Test Results of First Mill Trial

	Dry tensile, lb. per $^1/_2$ in.	*Wet tensile, lb. per $^1/_2$ in.*
Regular tray (prior to test run)	12.9	6.3
Tray containing 2% AMRES 1420	16.7	9.1
Regular tray (after test run)	12.1	6.0

Above results are based on 40 samples each.

Fig. 1. Pulpboard tray with J. H. Hale peaches in place before closure

Thus, it was found that addition of 2% phenolic resin gave an increase of about 4 lb. per $^1/_2$ in. in dry tensile strength or about 30%, and of about 3 lb. per $^1/_2$ in. in wet tensile strength or about 50%.

Addition of the phenolic resin did not interfere with the production speed and no foaming or sticking to dies was observed.

The strength improvements led to the possibility of tray weight reduction, which, in turn, permitted the mill to save on furnish costs as well as on freight. Lightweight trays have also an added advantage in reducing the possibility of steam blows during clamping of the dies containing the pulp preform to the gas-fired mold.

Horticultural Testing

At this point, the only remaining question to be solved was the possible effect of the phenolic resin on fruits, especially apples, under long term storage conditions.

Prior knowledge indicated that a phenol-formaldehyde resin, precipitated with alum and completely cured, would become inert and would, therefore, have no effect whatsoever on food products during storage.

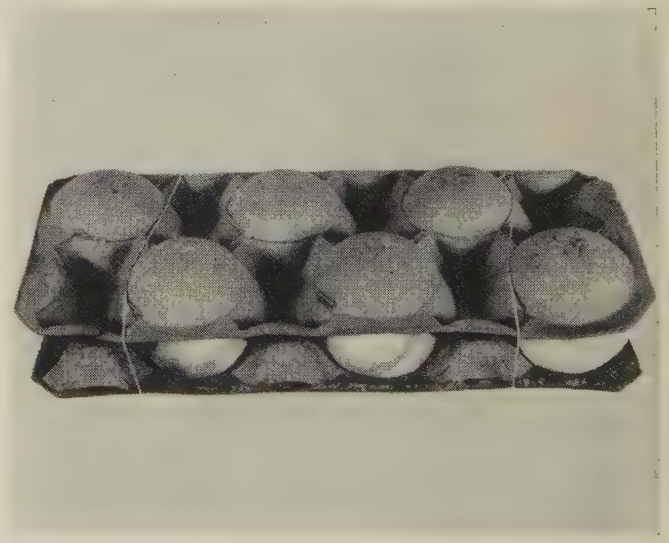

Fig. 2. Pulpboard tray with J. H. Hale peaches in place after closure

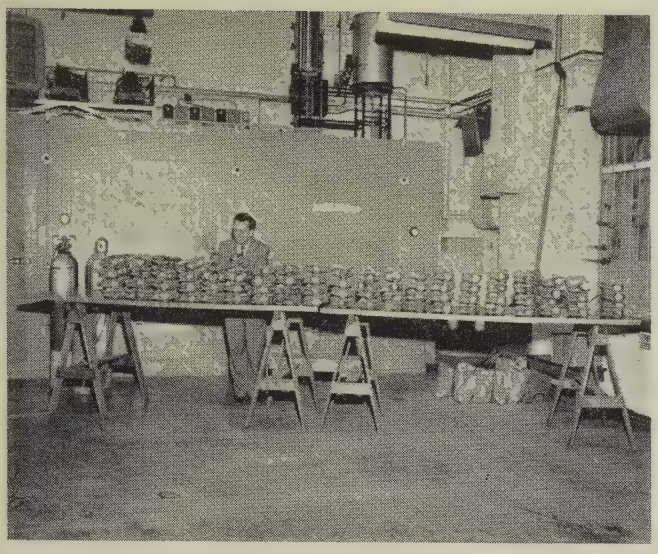

Fig. 3. Size of experiment for each fruit; 20 replications, four treatments

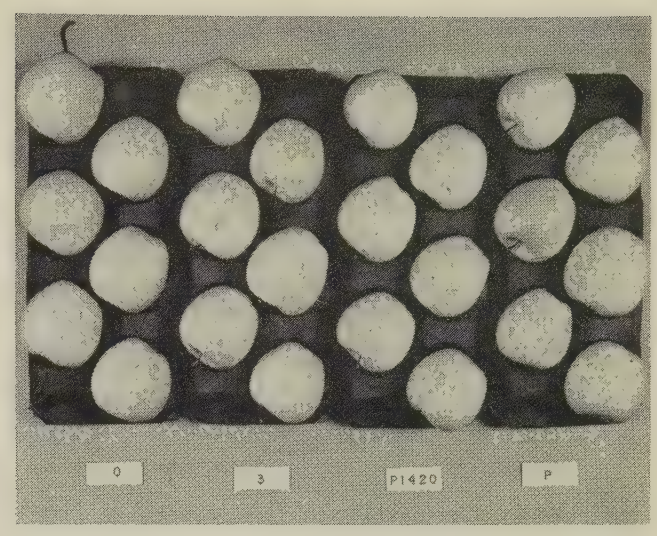

Fig. 5. Golden delicious apples after 4 months' storage and 10 days' ripening (0 = check, 3 = AMRES 210, P1420 = AMRES 1420 cured, P = AMSES 1420 uncured)

To substantiate this contention, a research project was set up at Washington State College, Pullman, Wash., Department of Horticulture, with P. C. Crandall in charge. The purpose of this project was to determine the effect of this particular phenolic resin on a number of fruits during storage in molded pulp trays containing this material.

Before the start of this study at Washington State College, two more mill trials were made at Pacific Pulp Molding Co. The first served to produce molded trays with phenolic resin when the resin was improperly cured. This was done to see if the undercured phenolic resin would affect the fruits. During a continuous mill operation, the possibility of improper resin cure due to temporarily lower oven temperatures is always in existence.

The second mill test was made to include a conventional cationic urea-formaldehyde wet-strength resin, AMRES 210, in the test program at Washington State College. During this test sticking of the pulp tray to the hot molds was observed. It was reported that the same adverse condition was encountered when other urea wet strength resins had been tried.

The project at Washington State College was started in September, 1956, with the final report being issued on April 1, 1957 (*5*).

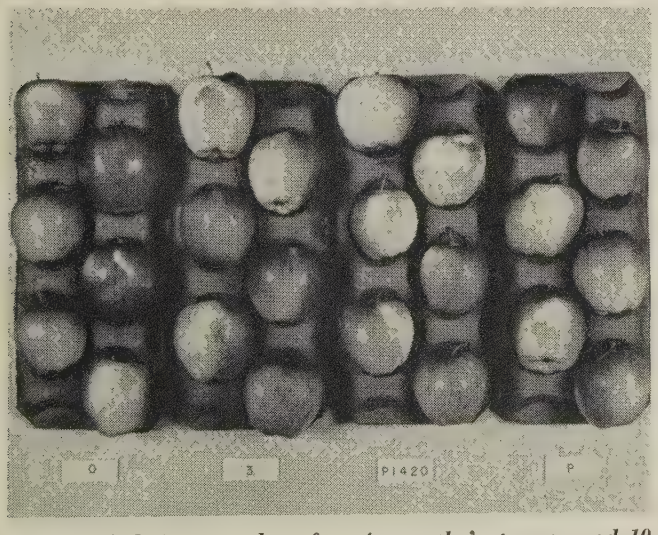

Fig. 4. Delicious apples after 4 months' storage and 10 days' ripening (0 = check, 3 = AMRES 210, P 1420 = AMRES 1420 cured, P = AMRES 1420 uncured)

Various fruits (J. H. Hale peaches, U. L. No. 1 Italian prunes, extra fancy d'Anjou pears, delicious and golden delicious apples) were placed in pulp-molded trays which had been manufactured with the resins to be tested. The trays provided for maximum contact with the surface of the fruits (Fig. 1 and 2).

Twenty units were made up for each treatment and for each type of fruit (Fig. 3).

Distilled water was placed into each tray pocket, so that the fruits rested in pools of water, to see if any harmful materials might be dissolved from the molded pulp trays. These containers were held for 3 months in cold storage at 32°F. At the end of this period, they were examined for any visible damage and then transferred to a ripening room at 70°F. After 10 days, the fruits were re-examined in detail for external signs of injury; some fruits were cut and checked for internal signs of damage, and finally tasted to see if there were any effects on flavor (Figs. 4 and 5).

The report concluded that molded pulp trays treated with the various resins, especially the phenolic resin—AMRES 1420, were much more resistant to disintegration and breakage than in treated pulp board. Trays containing phenolic resin were found to be extremely moisture resistant.

The resins (AMRES 210 and AMRES 1420) appeared to be noninjurious to fruits when used as impregnants of packaging materials. Testing was done under conditions that were more severe than would ordinarily be encountered during commercial handling and storage. None of the varieties of fruits tested were adversely affected by the resins.

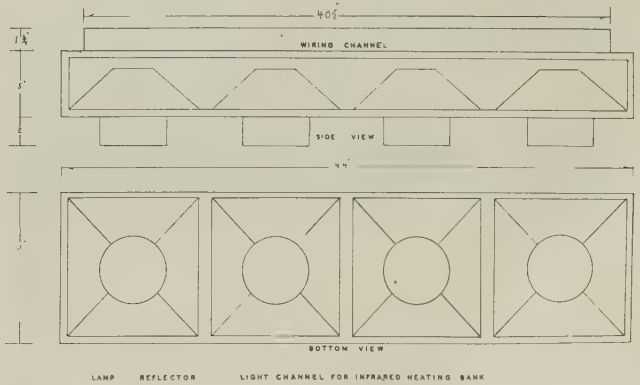

Fig. 6 Schematic of infrared quartz lamps

RESULTS AND DISCUSSION

When the foregoing report was issued by Washington State College, an extended mill trial of AMRES 1420 at Pacific Pulp Molding Co. was arranged to accomplish the following:

1. To improve the wet tensile strength of molded trays to a calculated average of 16 lb. per in. (each tray holding

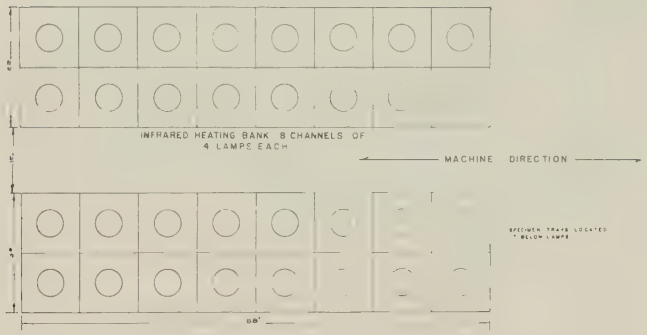

Fig. 7. Position of infrared quartz lamp unit

about 8 lb. of apples thus giving a safety factor of 2) by using AMRES 1420 as beater additive.

2. To determine the optima values for resin, size, and alum additions, as well as tray weight.

3. To evaluate and adapt phases of production to conform with resin usage.

On the basis of this mill trial, the standard furnish was modified. Increased yield of trays per ton of fiber through reduction of over-all tray weight and decrease in the amount of rosin size in the furnish practically offset cost incurred through resin addition.

The following operational changes were suggested and instituted:

1. Additional water added at the headbox to obtain a lighter wet tray weight.

2. Raise oven temperature to maximum output to obtain satisfactory resin cure.

3. Installation of new suction equipment to reduce initial moisture content of trays.

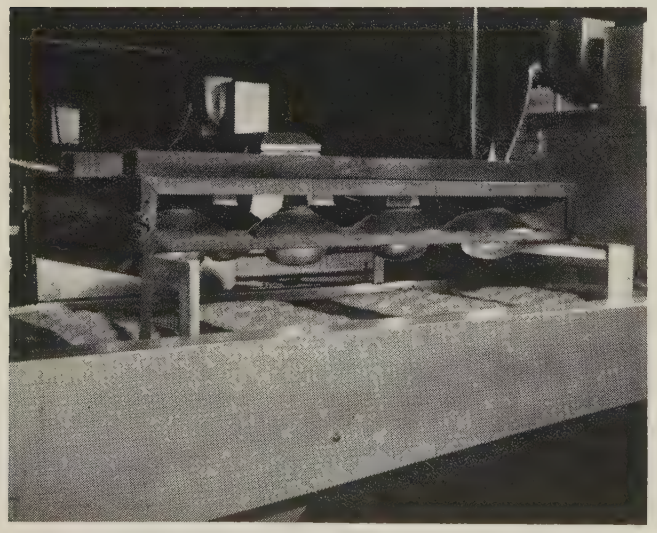

Fig. 8. Infrared drying equipment

Sewage effluent samples were obtained to determine phenolic content and biochemical oxygen demand. Analyses showed no phenolic content and a B.O.D. figure acceptable to the State Pollution Control Department.

In order to accomplish satisfactory resin cure an infrared heating unit was installed.

This unit containing eight reflectors with four 1000-watt quartz lamps was placed at the end of the conventional drier section. The lamps were positioned 5 in. above the conveyor belt. The length of the infrared unit was adjusted to provide an exposure time of 6 sec. (Figs. 6 and 7). The use of radiant energy in this pulp molding production line has enabled the mill to run the molding machine with higher speed and effiiciency.

The new drying equipment hardly required any additional space, the line did not have to be altered, and the installation could be effected without costly shutdown or rebuilding (Figs. 8 and 9).

CONCLUSIONS

Through the use of synthetic resins of specific types, upgrading of molded pulp products was successfully accomplished.

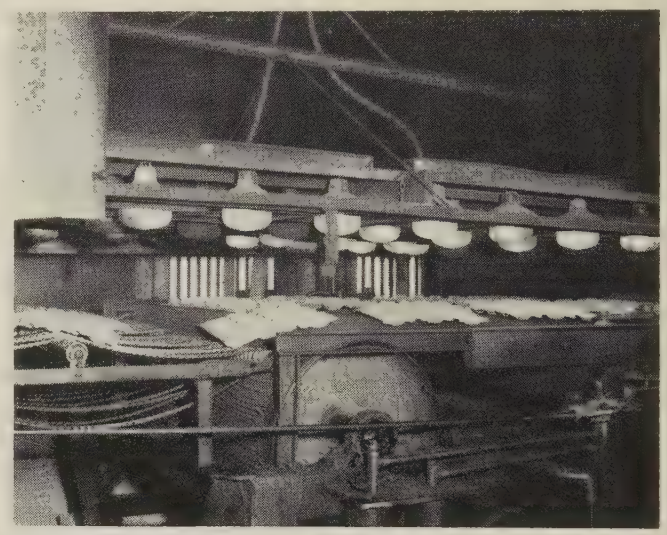

Fig. 9. Infrared drying equipment

The use of infrared as an additional heat source provided the necessary energy to effect the proper curing of phenol-formaldehyde resins in the pulp molding industry.

Experience gained in this particular operation opens many new possibilities for quality improvement of various grades of papers manufactured on different types of production equipment.

Increased stiffness of linerboard, permanent wet strength, improved paper surface properties, superior sizing are only a few of the highly desirable effects that can be obtained through the use of these new synthetic resin demonstrated in this project.

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Fresh Water Quality—Its Effect on Product Quality in the Pulp and Paper Industry

II. Some Biological Aspects of Water Quality

A. V. DELAPORTE and L. T. VLASSOFF

The industrial importance of bacterial capsular material is stated, and its significance in "slimes" is discussed. Some of the factors affecting the metabolic processes of microorganisms of industrial significance are reviewed. The value of research into the use of enzyme inhibitors as a means of checking bacterial capsule production, is suggested as part of a program aimed at freeing industry of troublesome slimes.

SINCE the early days, in the history of microbiology, a number of books on the microbiology of water have been written. European countries, particularly Germany and England and more recently Russia, have more than matched the contributions from the Western Hemisphere with the result that the major facets of water microbiology have been covered. General patterns have been established regarding the many forces at work in water such as the effect of pollution, self-purification processes, natural pollution, and the effect of organisms causing color and turbidity. In addition to texts, numerous articles are published throughout the world each year advancing new concepts in many fields, such as techniques in water testing or modifications of former methods. Not only are they being turned out in large numbers, but their interpretation is handled at many levels. A range of publications from those regarding science for the sake of science, to the informative manual distributed by pesticide companies is available, so that even microbiology, from the gardener's point of view, has been dealt with. The point is that there is enough literature present in the field of applied science today, that, should a layman require information on a particular subject, a publication that he will understand is available.

Serving the paper industry, we have an excellent publication in the TAPPI Monograph series. Herein sections deal at length with the topic of microbiology for the paper industry, and the information required by mill personnel is available in a well presented form in these monographs.

Many papers have been written on the identification, development and control of "slimes" in the paper industry with the result that lists of the predominant organisms involved have been compiled. On looking over the literature, one will notice a feature common to most of the predominant groups—the production of capsular material. Because of the far reaching importance of this material in the production of "slimes," the scope of this paper will concern itself with the single major factor involved—the bacterial capsular material.

CAPSULAR MATERIAL

The word "slime" to most people immediately brings to mind a substance rotting or decaying, something transformed from its natural shape to a gelatinous viscous material. In industry, it is used as a synonym for anything referring to an organic biofouling agent, whether the substance in mind refers to an aggregation of pulp or to algae growth over a screen or filter. In microbiology, the word slime refers to the outermost coating of a cell which may vary from a thin, barely detectable layer, to a mass of material greater than the cell itself. It has been called the capsule, the outer layer, the slime, or gum layer. Capsules and slime are believed by some to be different morphologically and biochemically (*1*). The capsule is claimed to be part of a cell, adhering to it as a covering layer; the slime, a secretion that may part freely from the cell. As there is no convincing evidence to support these theories, in this paper the word capsule will be used where the bacteriological sense is implied; "slime," referring to the industrial term.

A large variety of nonpathogenic organisms carried by water are, however, of vital interest to the water bacteriologist and engineer, because of their normal tendency to produce capsular material. Because of the adhesive properties of this material, it tends to accumulate on surfaces and can increase in volume either through further bacterial growth or other metabolic activity, or by collecting and holding other insoluble debris from the water supply.

A brief word about cell structures is in order to orient in our minds the position of the capsule. A cell is composed of many parts, the major ones being the flagella, capsule, cell wall, cytoplasmic membrane, cytoplasm, nuclear structures (if any), and cell inclusions. The latter four exist within the cell wall and are of a clear, watery, or slightly viscous consistency, held together by the exceedingly thin cytoplasmic membrane. The cell wall is the structure that gives rigidity to the cell. Were it not present, rodlike and spiral bacteria would never be seen, since, in the conditions under which the cell exists, the forces tending toward a sphere are relatively enormous.

The cell wall's chemical composition is not well established, since it varies with species and growth conditions (and other unknown factors), although studies indicate the existence of carbohydrates such as cellulose, chitinlike compounds, mucinoids, and hemicellulose.

Located on the outer surface of the cell wall, are the flagella threads and the capsule. The flagella are long, very firm threads of protoplasm streaming from the cell in various numbers and positions. These appendages are generally thought to serve as a means of locomotion for the organism (*2*), although some question the belief that flagella are responsible for motility (*3*).

The capsule layer is extracellularly located, appearing immediately on the outer surface of the cell wall. Chemically it is composed of high-molecular-weight polysaccharides, which may vary in composition from species to species and with available nutrients. Some are polymers of a single sugar (dextran by *Leuconostoc* van Tieghem), others, polymers of several sugars. In nature there are several composed of polypeptides (*Bacillus anthracis* Cohn, polymer of (D-glutamic acid) and some of lipids or lipid-protein.

Forsyth and Webley (*4*) have shown that species well distributed in soil will synthesize capsules of polysaccharides from sucrose and monosaccharide sugars. Chemical analyses of polysaccharides synthesized, distinguish five types: (1) levan (levulose polymer), (2) glucose and uronic acid, (3) glucose, mannose, and uronic acid, (4) glucose, mannose, rhamnose, and uronic acid, and (5) glucose, mannose, xylose, and uronic acid.

Physiologically, the function of the capsule cannot be precisely defined and is no doubt different for different bacteria, as the contact with the outer world. The capsule doubtless protects the cell wall against harmful influences. Many capsulated strains of pathogenic bacteria are not readily phagocytized by the leucocytes, and thus the capsule contributes to the virulence of the organism. A second function, attributable to some capsules, is the storage of reserve materials. It appears that not all capsules are utilizable as a source of energy for growth or maintenance by the organisms that produce them, but some definitely are. In these cases, it is of survival value to the organism to convert some of its nutrient into a form which can be reutilized by it, and perhaps by it alone, when nutrient becomes limiting.

A third function of still other capsules is the accumulation of a waste product. An example is an organism that ferments sucrose, using only the fructose part of the molecule. In

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CONCLUSION

Capsular material production is of such far reaching significance in the paper industry, that is may be considered foremost as a nuisance problem. The observation that capsule production is common among the bacterial flora predominating in "slime," may be used to advantage when means of treatment are in view. Since capsule production is the function of an enzyme system, research on the use of enzyme inhibitors should aid considerably in checking "sliming" conditions.

The addition of a substance blocking the production of capsular material (a compound that may prove bactericidal or bacteriostatic) and the enforcement of other preventive measures such as the adjustment of nutrients, pH, and temperature, can do no other but enhance the effect of chemical treatment (if indeed, it is still necessary). It is much easier to advocate chemical treatment; but less expensive to use research methods.

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Latest Trends in Raw Materials and Process in the Insulation and Hardboard Fields

LEE EBERHARDT

Insulation board and hardboard are relatively newcomers to the building products field. The industry has grown from two plants producing less than 100 tons per day end product in 1925 to an industry of some 40 plants producing nearly 8000 tons per day. This is certainly a phenomenal industrial growth, matched by few others in North America during the same period.

The industry is unusual also, in that, all of the pioneer producers are still around today, larger, stronger, healthier, and with a bright future. Some of the pioneers and founders of the industry who had so much to do with developing the fundamental processes, equipment, and end products are still members of TAPPI.

It is unusual to be able to go back seeking historical data on an industry in preparation of a paper, such as this, with so little difficulty. In many cases all that was required was a phone call to obtain factual information from direct participants.

Going back to the beginning, the insulation board industry as we know it today was born in the early twenties when the first board was produced from poplarwood by modified stone grinders. Shortly afterward bagasse entered the picture. The first hardboard from exploded pinewood was made in the late twenties.

The early equipment utilized in the processes was, in general adapted from the paper industry where possible. Many new machines and ideas had to be developed. That only a few additions have been required to date is a tribute to the ingenuity and soundness of thinking of the pioneers. Technologically, the industry has progressed rapidly.

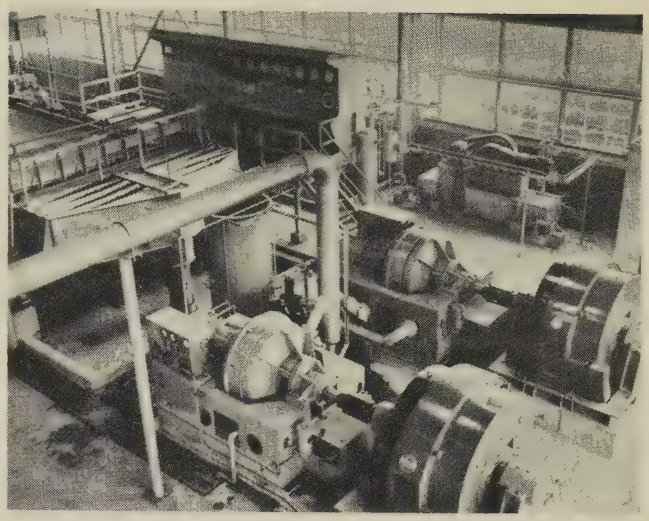

Fig. 1

The industry was handicapped in the beginning by the necessity of gaining acceptance in the market place, facing the stiff competition from prejudice, traditional materials, product unfamiliarity of the building designers, architects, contractors, and labor. About the time some momentum and acceptance had been gained, the depression of building activity of the early thirties delivered an almost fatal blow. By 1935 there were 13 producing mills handling a modest 1200 tons per day of end product. Straw, wastepaper, and wood waste had entered the raw material picture, the vacuum cylinder board former and the Bauer double disk refiner had been developed, and use of digesters became accepted practice replacing cruder previous methods, i.e., shredders, stone roll beaters, rod mills, etc.

The acceleration of building activities, in the late thirties, the wartime housing boom of World War II, and the accompanying labor shortages of the period provided wider acceptance of the industry's end products, and a sizable increase in the number of plants and end product tonnage resulted. This period also marked the appearance of the defibrator and the beginning of the continuous methods in wet end stock preparation. The fourdrinier also appeared on the scene during this period.

World War II was followed by an unprecedented expansion in the industry during the five-year period 1945 through 1950 the end product tonnage nearly doubled. Most of this expansion was due to speedup and new machines installed by the traditional producers, however, four new mills were added by newcomers. This period also marked the beginning of mass prefabrication in housing, large-scale housing developments etc. These trends were in favor of the industry's products at the expense of traditional materials and techniques with their high labor requirement.

This era saw the development of continuous digestion methods in the introduction of the Rapid Cycle digester system, the Pandia, and Grenco digesters. These were accompanied by improvements in other equipment and processes. The trend toward automation and continuous wet end methods was accelerated by increasing labor cost and the necessity of reducing manpower requirements.

The period was also highlighted by a considerable broadening of the research and development phases of both end product and process. This resulted in a big expansion in tonnage and many new processes. Ideas such as particle board, semidry hardboards, flake boards, etc., provided a distinct break from traditional concepts and methods. These changes resulted in the entrance of many new producers and new products into the board field.

The period of 1950 to present resulted in nearly doubling the end product tonnage and number of producing plants.

Table I. Daily Tonnages of Various Raw Material Utilized in the Production of Hardboard and Insulation Board. Years 1930–58 (United States, Hawaii, and Canada)

Year	*1930*	*1935*	*1940*	*1945*	*1950*	*1955*	*1958*
Total tons[a]	870	1197	2310	2942	4389	5659	7405
Hardwoods	285	380	490	490	655	808	1828
%	33	32	21	16	15	14	25
Softwoods	260	210	990	1805	2457	3689	4067
%	30	18	43	60	56	65	55
Bagasse	300	310	670	670	1000	1000	1000
%	34	26	30	22	23	17	15
Wood waste	None	110	150	172	407	1234	1490
%		9	7	5	9	20	20
Other[b]	25	90	160	197	247	342	367
%	3	8	7	6	5	6	5

[a] Based on 3 *M* sq. Ft. per ton 1/2-in. insulation board or 1/8-in. hardboard.
[b] Includes wastepaper, spent wood, licorice root, straw, etc.

Many of the newer processes have been commercially proved and the end product range broadened again at the expense of traditional materials.

The period also witnessed the introduction of the Deculator for air removal from stock and the Bauer Pump Thru refiner as a secondary or tickler unit ahead of the forming machines. Both ideas have been accepted, proved in service, and are fast becoming standard applications in the industry. New end product quality levels have resulted. Figure 1 illustrates the Pump Thru unit as installed at National Gypsum Co., Mobile, Ala.

The trend toward continuous methods and automation reducing labor costs has been accelerated. Competition for raw materials has led to an increase in the utilization of cull hardwood species, wood waste, and wood residues. Climbing freight rates in a freight allowed business have added incentive to dispersion of plants to serve local markets at lower freight costs.

RAW MATERIAL UTILIZATION 1930–1958

Table I and Fig. 2 indicate the changes in the raw material utilization in the period 1930 to date. Examination of this information indicates the following significant items.

1. Hardwoods after holding fairly steady percentage-wise have taken an extraordinary jump in the past 3-yr. period.
2. Softwoods remain the predominant raw material of the industry and will probably remain so until competition from other sources force a change or the available soft wood waste sources dry up due to complete utilization and competition.
3. Bagasse usage is gradually dropping off percentage-wise primarily due to the fact that the supply is limited in the area under consideration. World-wide, however, this is not the case.
4. Straw has nearly dropped from the picture in favor of wood, some wastepaper is still used.
5. Wood waste utilization has shown a substantial gain in the past ten years due primarily to the fact that it is the most available raw material in lumber producing regions which have seen expanded activity in the board field in recent years with new plants in such areas.

PROCESSES 1930–1958

Table II and Fig. 3 indicate the changes that have taken place, process-wise, in the industry in the period of 1930 to date. These changes have been primarily due to the development of improved equipment, automation, and continuous processes. High lights of this information are as follows:

1. Steamed wood has shown a decided increase in recent years and at present has caught up with groundwood. This trend has been primarily due to development of suitable equipment such as: The Rapid Cycle digester, Grenco, Pandia, and improved Defibrator.

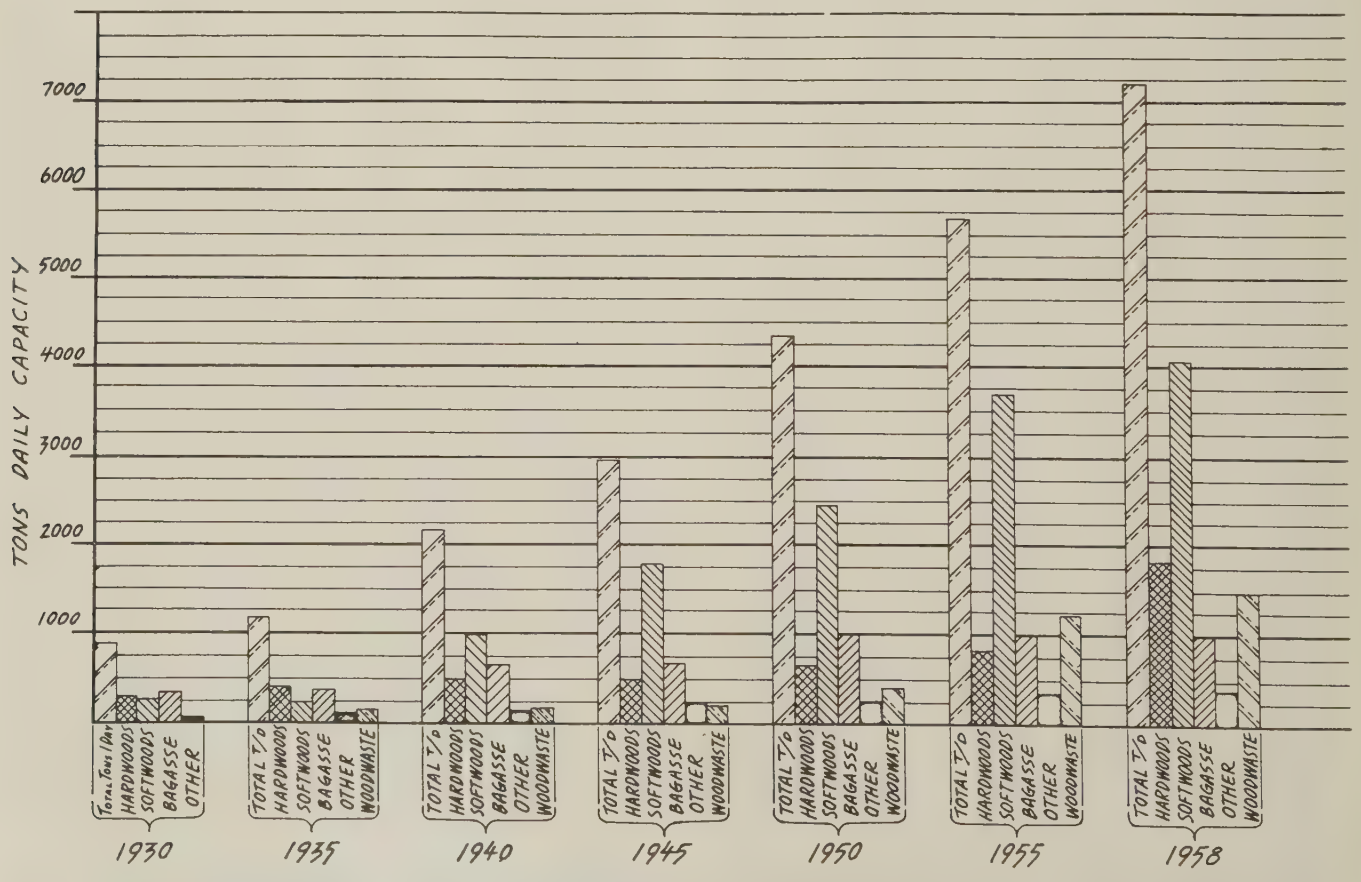

Fig. 2. Daily tonnages of various raw materials utilized in the production of insulation and hardboard, 1930–58 in United States, Hawaii, and Canada

Table II. Processes Utilized in the Production of Insulation Board and Hardboard in the Years 1930–58 (United States, Hawaii, and Canada)

Year	*1930*	*1935*	*1940*	*1945*	*1950*	*1955*	*1958*
Total tons	870	1197	2310	2942	4389	5659	7405
Steamed wood	...	125	165	195	500	1075	2008
%	...	11	7	7	12	19	27
Groundwood	415	415	765	938	1465	1585	1985
%	48	34	33	31	33	28	26
Exploded wood	100	210	550	850	900	1300	1300
%	12	18	24	28	20	24	17
Defibrated wood	...	...	70	300	570	1021	960
%	...	...	3	10	13	18	13
Continuous process	...	...	...	...	175	314	1215
%	...	...	...	...	4	6	16
Chemicals	45	190	310	402	502	617	1477
%	6	15	13	13	12	11	20

2. Groundwood is gradually dropping percentage-wise primarily due to inability to utilize wood waste in chip form and lack of success on hardwoods except lighter density species such as poplar, cottonwood, etc.

3. Exploded wood has gradually dropped behind due to development of newer equipment.

4. Defibrated pulps have lost ground after initial acceptance as the first continuous digestive method.

5. Continuous automated processes are rapidly increasing.

6. Chemical treatment is increasing with the upswing in the utilization of hardwoods and higher end product quality demands.

FUTURE TRENDS AS INDICATED BY ECONOMICS

So much for the past. Let us now examine and discuss present and future trends in raw material, process, and equipment. Perhaps the best approach is to take a look at the economic atmosphere and then get down to the various subjects.

I believe we can assume a continuation of inflationary trends in the foreseeable future. This, of course, means higher labor, freight, and raw material costs. Population growth and shifting indicate broadening markets along with changes in traditional marketing areas as population expands to the south and west. Dispersion of industry following the population trends cannot help but upset the industry's marketing patterns.

Inflationary trends also are accompanied by increased customer resistance to end product price increases. Competition with traditional materials such as lumber, plywood, gypsum board, etc., is also a limiting factor on prices.

Another factor that must be considered is competition for raw materials. Our neighbor and big brother, the paper industry, is gobbling wood at an enormous rate and anticipates a considerable expansion to meet the needs of expanding population and markets.

What does all this mean as far as the future of the board industry is concerned? I believe it can be summed up as follows:

1. Higher labor and raw material costs mean accelerated use of highly automated processes utilizing hardwoods and wood waste materials primarily in chip form.

2a. Increased freight rates in a freight-allowed business means industry-wide dispersion to a number of locations close to the market areas.

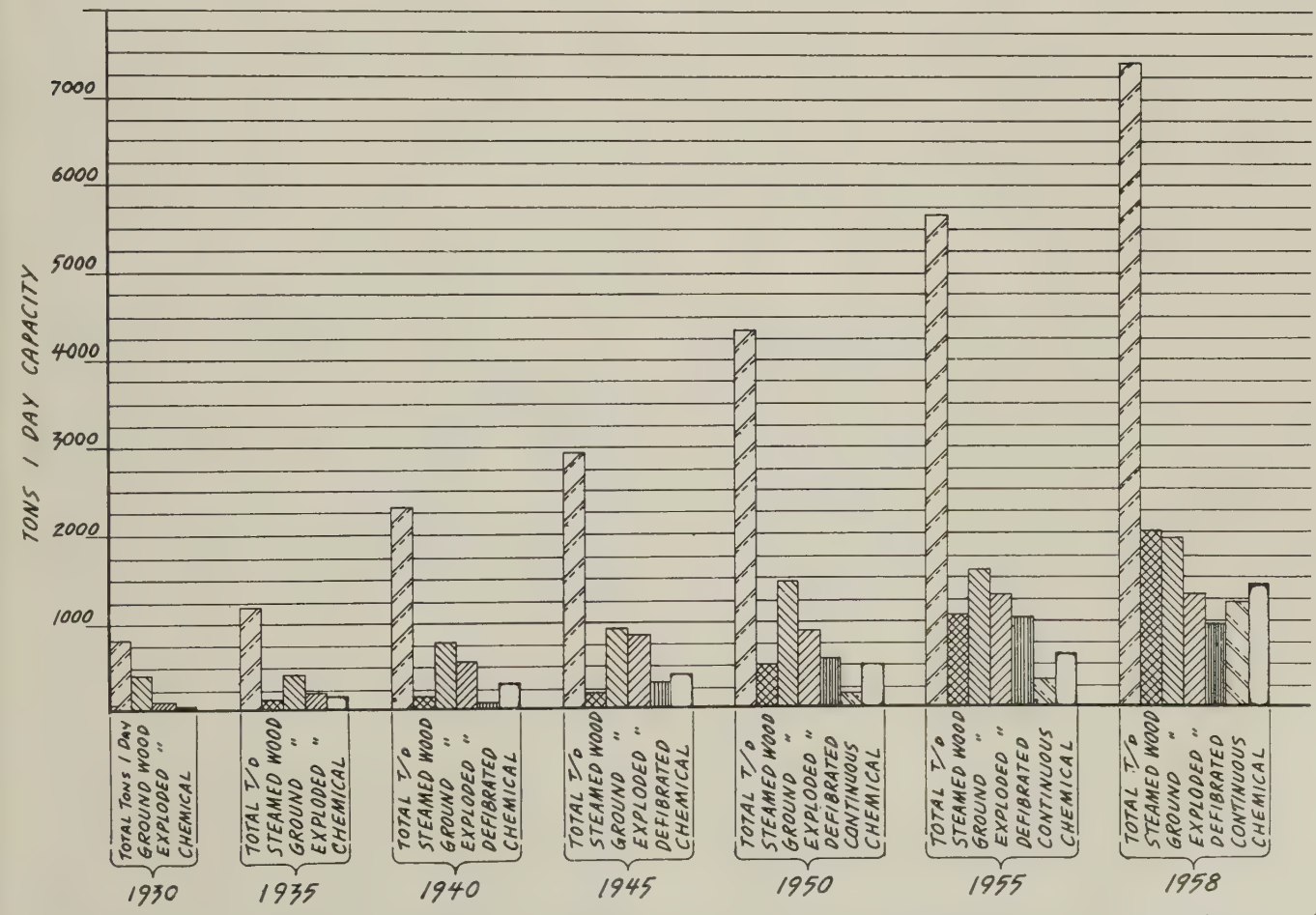

Fig. 3. Processes utilized in the production of insulation and hardboard in years 1930–58 in United States, Hawaii, and Canada

2b. Dispersion will also be hastened by necessity of offsetting high cost of nation-wide advertising campaigns in TV and magazines with adequate sales, merchandising, and manufacturing facilities.

3. Over-all capital cost of plants must be held down without sacrifice in efficiency, to assure decent return on investment, and reduce end product cost due to depreciation charges.

In short, it would appear that the ideal plant of the future would be a highly efficient, automated, low captial cost plant producing a wide variety of end product from hardwoods and wood waste materials located close to the market areas.

This may paint a rather black picture when approached from a traditional conservative viewpoint, however, such a concept is within reach today by utilization of existing techniques, processes, equipments, and methods.

PLANT DISPERSION TO COMBAT FREIGHT COSTS

Plant dispersion to areas closer to the markets to combat freight rate increases is an economic problem facing the industry. This phase is in a somewhat different area, since it involves sales and marketing analysis to determine desirable location of plant sites to best serve the present and future markets.

Raw material supplies, water volume and quality, and plant end product demands are, of course, very important in location of plant sites and, for this reason, the research and production personnel have an indirect interest.

I believe the following assumptions can be made in this respect: any West Coast expansion will probably be based upon softwood waste and the location would be south of Portland, Ore.; expansion in the East would be based upon hardwoods since the logical areas such as New England, the Ohio, Missouri, and Mississippi Valleys together with the Middle Atlantic States are predominantly hardwood areas. Utilization and processes therefore must be tailored to the expected raw materials.

To confirm the above trend one merely has to examine the map of the United States and Canada and pin point the location of the plants built in the past five years. Here we have seen several of the traditional producers disperse and new producers enter locations where good economic situations exist. The gypsum board industry is an excellent example of the pattern, exaggerated perhaps by the extreme weight of the end product.

Utilization of Hardwoods

As indicated previously there is a definite trend toward utilization of lower cost hardwoods. At present several mills have found that steaming, with or without chemical treatment, will produce an acceptable substitute for softwoods as a major portion of board machine furnish and on some end products 100% can be hardwoods.

The denser, lower-cost hardwoods of the predominant species available such as oak, maple, birch, etc., are naturally darker than most softwoods and less dense hardwoods like poplar and cottonwood. This darkening becomes more serious with steaming or chemical treatment to improve strength properties and is a definite limitation on acceptance.

This situation can be partially resolved by use of coatings, channeling hardwoods into end products such as asphalt sheathing where color is not important, thereby allowing concentration of lighter colored woods in critical end products.

Another possibility is borrowing the secondary headbox idea from the kraft industry and overlaying the dark base sheet with a lighter colored top liner.

It might also be possible to produce some interesting fissure-type acoustical tile with the combination of the dark base stock showing through the lighter top liner furnish. Or perhaps we could add pigments such as clay, titanium, or silene to brighten the liner much in the same way coatings are presently utilized for the same effect.

The Sunbury plant of Allied Chemical and Dye Corp. and the Templeboard plant at Diboll, Tex., are recent examples of plants utilizing high percentages of hardwoods (oak being the predominant wood species) in their board furnishes. The former utilizes a caustic cook in continuous digesters followed by Bauer double disk refining or primary pulp and machine control using a Bauer Pump Thru type refiner.

The latter plant has a fully automated Rapid Cycle digester system followed by double-disk refiners.

Wood Waste Utilization

Wood waste utilization presents other problems in that the material source is generally located away from the plant site. This means the mill lacks control of chip quality and nonuniformity of chips due to difficulty of chipping or hogging, and inadequate equipment and its maintenance must be anticipated. The material must be transported and stored which in turn means possibility of contamination and changes in moisture content of chips. There is a definite lack of knowledge of storage problems and losses in many areas. These may appear to be minor problems but many recent experiences indicate otherwise.

Bark content in wood waste is another definite limitation in utilization and supply. If a mill insists on completely bark-free waste, the immediate supply becomes limited since the great majority of small producers who cannot afford suitable whole log barking equipment are eliminated as producer sources. To exploit such wood waste sources the mill must aid in financing the required equipment, or set up a graduated price based on bark content and contamination discounting the yield loss and cost of clean up. In the latter case the mill itself must be adequately equipped to handle the lower grade materials.

The mill that proposes to utilize wood waste in substantial volumes must assume that hogged or chipped sawmill and residue waste requires special treatment and must be prepared to handle a material that has the following characteristics:

1. Nonuniformity of chips—slabs, edgings, and residues under the best conditions will not provide pulp mill quality chips obtained from round wood at the mill.
2. Bark content as high as 20% from unbarked slabs and edgings.
3. Nonuniformity of moisture content due to variation in material, pile storage, weather, etc., over which there is little control. There is always the possibility of dry trim, plywood clippings, and kiln-dried material.
4. Contamination due to storage and handling. If rail cars and trucks are involved the chips can contain practically anything that was hauled in same, plus any other trash picked up in transit or storage.

At present there is probably not a mill in the country that is adequately prepared to handle such materials with their present woodroom systems, this also applies to the pulp mills. As more wood waste finds its way into the industry, the problems are becoming very apparent. There is also a growing awareness that raw material uniformity is one of the most important factors in producing uniform high quality end products.

WOOD WASTE SYSTEM

Nonuniformity of chips can be adequately handled with an abrader followed by proper screening. The abrader is a large heavy duty slow speed swing hammer mill that works on the impact principle. This unit knocks bark loose from the wood and shatters friable bark. The chips are reduced along the grain to produce a good uniform small sized chip.

Figure 4 is a picture of an abrader installed at the Allied Chemical Corp., Sunbury plant. This unit handles 35 cords per hr., with 50 hp. applied. The unit is not quite large enough, to handle full chipper surges of 50 to 100 cords per hr. rate. This unit has provided excellent results and it is prob-

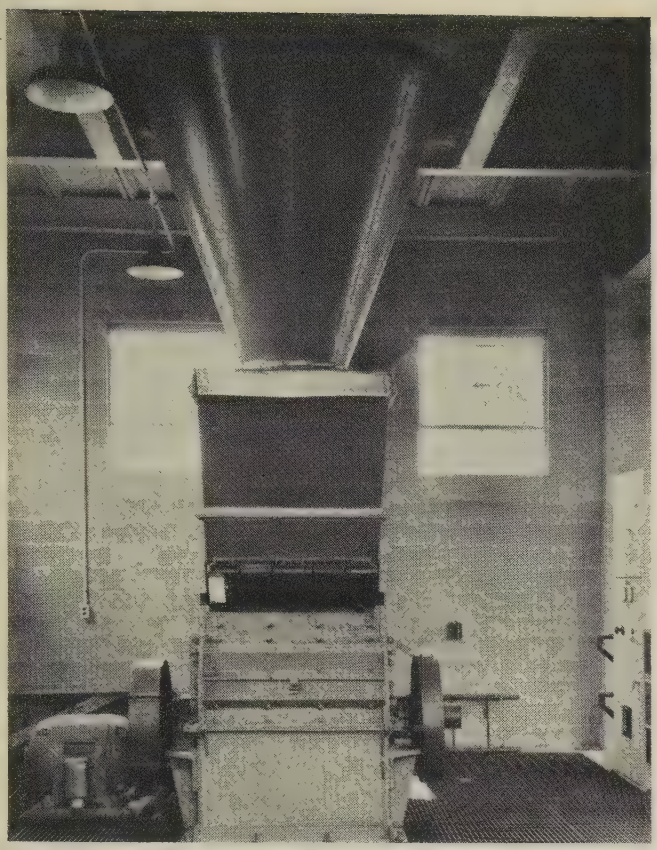

Fig. 4

able that the excellent uniformity of digestion obtained with the continuous digesters in this mill is due partly to the abrader. Several other installations are going into operation in the near future, using a higher capacity unit.

The abraded material is then screened on a two-deck screen of conventional design, it is important, however, that the screen not be overloaded and a distributing feeder is essential, there is also an indication that a perforated metal deck is preferable to conventional wire mesh.

The sawdust deck of the screen will remove a substantial percentage of bark fines along with chipper sawdust, the oversize are returned to the abrader. We have found that by juggling the size of the perforated decks it is possible to provide a very uniform material of any desired degree of fineness from full chips down to "pin" chips.

We have also found that the above treatment will remove at least 50% of the residual bark on most wood species and in some cases nearly 100% removal is obtained. Some recent work indicates that with the addition of air aspiration to the screen it is possible to make a very accurate separation of wet chips from dry. In which case it would be desirable to cook separately.

Any bark that remains in the chips can be removed from the pulp following digestion and refining by the use of Bauer cleaners. The cleaner rejects can be sewered or refined further and put back in the board.

CHIP WASHING

Another recent addition to the train of woodroom equipment is the U. S. Gypsum chip washer. This unit was developed at the U. S. Gypsum, Pilot Rock, Ore., board mill and consists of a riffler box followed by an inclined drainer screen section.

The chips in this case are dumped in a circulating water stream flowing over the rifflers and are then dewatered on an inclined mesh belt drainer. The drain water returning to the head end. This unit has proved very effective at removing all heavy trash materials from chips. It is amazing the variety of stuff removed including gravel, rocks, spikes, nails, bobby pins, knots, sand, fly ash, etc.

As a result of installation of this unit plate life on the Bauer double-disk refiners has nearly doubled, chip moisture to the Rapid Cycle digesters is more uniform, and it is probable that other maintenance costs will drop due to longer wire, agitator pump, and stock line life.

Conventionally, tramp materials have been removed from chips by means of magnetic pulleys, grates, chute magnets, and the like, these units have been fairly effective on magnetic materials, but unfortunately, such materials only make up a minor percentage of contaminants. The chip washer provides a much more effective and efficient means of removing all heavy trash.

This unit has one deficiency in that the riffler section is difficult to clean without shutting the unit down to remove the accumulated trash. This has been eliminated in the latest design by use of a magna cleaner replacing the riffler. The magna cleaner allows trash removal on the "fly" and is somewhat more efficient.

Bauer Bros. Co. has been licensed by the U. S. Gypsum Co. to commercialize and merchandize the chip washer in the industry.

The combination of abrader, accurate screening, and the chip washer provide a very effective system for preparation of chips for board and pulp mills. Regardless of condition prior to the system, the chips will be delivered to the digesters at uniform size and moisture and relatively bark free. The residual bark can be removed from the refined pulp by use of Bauer cleaners if necessary to maintain end product quality.

FUTURE TRENDS IN WET END PROCESSING

Wet end processes have been touched on briefly in earlier portions of this paper. The conventional processes can be dismissed from the discussion in that there will probably be little change other than increased automation and more efficient systems as improved equipment is introduced by the equipment builders.

Groundwood from chips, and chemical modifications of the same appear to provide excellent possibilities for future board mill expansion and modernization. Pulps of these types are relatively new and are not presently utilized in the board field although they are rapidly expanding in pulp and paper.

Pulps of these types are produced by multipass disk mill refining with or without pretreatment with chemicals. In general, this type of treatment will produce from chips pulp quality equal or better than the same material ground on conventional stone grinders. Chemicals such as cold caustic and hot sodium sulfite will provide a considerable pulp strength improvement over straight mechanical pulps and in many cases the improvement is enough that marginal species can be utilized, particularly the hardwoods.

The system consists of an impregnating vessel such as the Rapid Cycle digester, a Pressafiner for extraction of the surplus liquor for re-use, two stages of disk mill refining in which the Bauer double disk appears to be mandatory as the primary. Following refining, the pulp is handled conventionally.

Most of the activity using these processes to date has been on hardwoods. It is definitely proved that pulps superior to spruce groundwood can be produced from such cull species as oak, birch, beech, maple, etc. Some very interesting pulps have been produced from softwoods using a hot neutral sulfite liquor impregnation. Board produced by the latter method was extremely light and strong with good color characteristics.

It appears to be an excellent pulp for blending with poorer quality materials to produce improved strength and lower board weight.

The above method has been applied in the production of paper pulps at Gould Paper Co., Bowaters Southern, and

Blandin Paper Co. in the United States. Three plants in Japan and one in Italy are also in operation. Considerable laboratory evaluation indicates a bright future for these pulps in the board field.

MULTIPURPOSE PLANTS

There is one interesting feature of these processes, the train of equipment consisting of digestion or impregnating vessels, Pressafiners, disk refiners, screening and cleaning, stock preparation ahead of the forming machine, is exactly the same for the production of steamed wood, groundwood from chips, cold soda pulps, and semichemical pulps. The application could be extended to high yield or normal yield chemical pulps since all of the essential elements are incorporated in the system.

The above points out a very interesting possibility that of a central versatile pulp mill containing the above elements providing the entire fiber requirements for most end products of a building products merchandizing organization. With the addition of a wastepaper system it would be entirely possible to produce the following end products:

Insulation board—steamed wood and/or groundwood from chips.
Hardboard—steamed wood.
Roofing felt—steamed wood, groundwood from chips and/or wastepaper.
Gypsum liner board—semichem, groundwood from chips and/or wastepaper.
Building papers—high yield chemical pulps, semichem and/or wastepaper.
Bags & paper—chemical pulp, and/or wastepaper.

Carrying the idea one step further: if a plant were located near the market at a location with low cost wood, water, and gypsum rock, practically the whole line of end products could be produced in the single integrated plant, warehoused at the plant, and mixed lots moved by barge, truck, and rail to the nearby market.

All of the elements of such a plant are known, all we have to do is combine the different plant types, integrate the common features, apply complete automation and control. Such a plant could not be touched competitively within the radius a truck could load, deliver, unload, and return in one working day. Perhaps this is our building products plant of the future.

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Microbiology of the Purification of Polluted Waters

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THE implication in the title of this paper that there is a special field of microbiology in aquatic environment, one different from that in soil and air, does not mean that the basic biological principles and processes in aquatic environment are different from those elsewhere in nature. Although some soil, intestinal, or air organisms are found in water and vice versa, it is believed, however, that in an aquatic environment the processes are brought about by a specialized group of microorganisms which find their natural habitat in this environment.

The purpose of this paper is to discuss briefly the microbial transformations in polluted waters, from the standpoint of fresh waters, although there is no reason to believe that the basic principles involved are different from those in salt water, even though the organisms involved may be different.

Water has a complex microbial population of protozoa, algae, fungi, and bacteria. Each of these groups, consisting of many genera, fulfill an important function in the ultimate stabilization of pollutional matter. There are complex ecological and physiological interrelationships between groups as well as between the various genera and species within each group. The relationships may be associative, competitive, symbiotic, or antagonistic. Many of the transformations are brought about by the associative action of a number of different species working in tandem.

The protozoan and algal populations of streams have been studied more extensively than the bacterial population, with the exception of the coliform organisms, because the identification of protozoa and algae can readily be accomplished microscopically whereas that of bacteria species requires much more time and effort. The studies with algae and protozoa have been primarily from the standpoint of utilizing them as pollution indicators. The protozoa undoubtedly play an important role in the stabilization of pollutional material, and the algae in photosynthetic reaeration. But little is known specifically about the role played by protozoa in the stabilization of the organic matter beyond the recognition that some of them are active bacteria feeders and thus indirectly and beneficially affect the stabilization of the organic matter by keeping the bacteria in a state of multiplication.

Recognizing the complex and intimate relationship between these four major groups of microbes, it is still necessary to limit this discussion to bacteria alone. Even with this limitation, discussion of the types and activities of bacteria in water will have to be greatly restricted and necessarily generalized.

In addition to this writer's predilection, the justification in selecting bacteria instead of the other groups is that bacteria are the most important organisms in the stabilization of pollutional material and are at the base of the biological chain.

When we consider the differences in the physical and chemical environments in water as compared with those in soil, animal intestines, and air, it can be readily appreciated that certain adaptations to the environment must have taken place, developing specialized forms for each environment. The main physical characteristics of water are its fluidity, flow, and circulation. Even polluted water should also be considered as a substrate low in nutrients for the growth of microorganisms, and in this respect it is more similar to unmanured soil; but it is different from the nutritive conditions in the intestines and certainly different in the artificial culture media commonly used in microbiological work.

Using B.O.D. as a yardstick of available organic matter, waters with only natural pollution would have a B.O.D. of 1 to 2 mg. per l. Streams moderately polluted by either domestic sewage or industrial wastes would contain B.O.D. of 4 to 5 mg. per l. Values above these indicate excessive pollution. This is then the range of food concentrations to which microorganisms in water have had to adjust in order to survive and grow, and thus we can expect microorganisms which are truly aquatic or native to water as differentiated from those found accidentally in water and whose existence there is only transitory.

The fact that some organisms can be found in great numbers in water does not necessarily ascribe to them a function. The coliform organisms commonly found in relatively great numbers in waters polluted with domestic sewage can be used as an illustration. The natural habitat of these organisms is in the intestinal tract of warm-blooded animals. There they are found in very large numbers (in billions per gram of feces), which can only be the result of multiplication under the prevailing conditions of food and temperature in the intestines. Although after being discharged into a water course they may be found in large numbers, these numbers decrease rapidly

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with time. It is not possible, therefore, to ascribe an important function to them in their logarithmic death phase. It may be argued that these organisms, despite their constantly decreasing numbers, also multiply but to an extent not sufficient to offset the higher death rate. Even if this is true, they cannot be important functionally. When these organisms, which are in primarily logarithmic death phase in water, are transferred to an artificial culture medium with suitable type and concentration of organic matter, they grow very readily and rapidly. In respect to public health hazards, enumeration of coliform organisms occupies a very important place in sanitary analyses of water, but in respect to the role played by these organisms in the purification of polluted waters, their enumeration sheds very little light. Thus, the abundance of bacteria in a culture medium is no indication of their physiological importance, but merely a sign of their ability to grow readily in culture media.

Contrariwise, failure of an organism to grow in culture media is no sign of its lack of importance. Many true water bacteria fail to grow in laboratory media. It is generally true that no single culture medium will permit growth of all the different bacteria, for bacteria have different nutritional requirements, and all these requirements cannot be incorporated into a single culture medium. In addition, true water bacteria, having adapted themselves to the physical and nutritional conditions prevailing in an aquatic environment, when confronted with higher concentrations of food in culture media, will have to make unknown and complex adjustments to this new environment in the same way that bacterial populations have adjusted themselves to the natural conditions in the water originally. Consequently it is impossible to determine their original activity in the natural habitat by the transformations brought about in the culture medium using indirect methods.

The methods for demonstration of the presence and numbers of these organisms must, therefore, correspond to the conditions prevailing in the aquatic environment, but there is no single satisfactory method by which they can be enumerated. In direct microscopic examination of water, functionally important and unimportant bacteria cannot be differentiated, nor can living and nonliving bacteria be thus differentiated. Between the Scylla and Charybdis of indirect cultural methods and of direct microscopic methods, information regarding the functionally important water bacteria has not progressed very far.

There is one approach, however, that has been used to a limited extent which is free from the objections leveled against the cultural and direct microscopic methods, that is the submerged microscopic slide technique. Microscopic slides are submerged into the water and allowed to stand for variable periods. When the microorganisms attach themselves to the submerged glass surface they can then be examined and enumerated microscopically or the amount of growth evaluated gravimetrically. True water bacteria have a propensity to grow attached, and more significant information can be obtained by the use of the slide technique than by the cultural or direct microscopic methods.

Due to lack of morphological differentiation in the majority of bacteria, microscopic identification of the various species is an unsatisfactory approach for the study of organisms responsible for the various transformations of pollutional materials in water. It is possible, however, to study the organisms according to their physiological activities either in artificial culture media or in their natural substrate, and numerous culture media have been devised for this purpose. Various portions of water are inoculated into these media and a specific transformation is determined. Bacteria have thus been classified as albumin digesters, ammonifiers, nitrifiers, sulfate reducers, sulfur oxidizers, sugar fermenters, urea splitters, cellulose decomposers, etc. It is apparent that many of these groupings are not mutually exclusive since bacteria have the ability to bring about many transformations. Conversely their ability to bring about these transformations in artificial culture media is no guarantee that they bring about similar changes in their natural habitat because of the differences in the environmental conditions in respect to types and quantities of food.

Study of the various activities by the naturally occurring flora in the natural substrate eliminates the objections mentioned. These activities may be grouped in relation to: (1) nitrogen changes, (2) oxygen changes, (3) transformations of carbon, and (4) transformations of sulfur.

Changes in nitrogen result from hydrolysis of proteins to amino acids and ammonia, oxidation of ammonia to nitrite and nitrate, reduction of nitrate to ammonia or nitrogen gas, and, finally, assimilation of ammonia or nitrate for the synthesis of cell protoplasm. Proteins are hydrolyzed to ammonia both under aerobic and anaerobic conditions, while nitrification can take place only under strictly aerobic conditions and the reduction of nitrate only when dissolved oxygen is absent. All these transformations take place in water and occupy an important place in stream sanitation. Anaerobic conditions and transformations prevail in the bottom deposits while aerobic conditions and transformations generally prevail in the flowing water.

Oxygen utilization is an important yardstick of the activities and transformations taking place in the water. It occupies an important position in sanitary analysis of water and is recognized as the biochemical oxygen demand. In stream sanitation the dissolved oxygen level, which is the result of the rate of biochemical utilization of oxygen and the rate at which it is supplied to the water atmospheric and photosynthetic reaeration, is of paramount importance from the standpoints of maintenance of fish life and prevention of nuisances.

Transformation of carbon can be studied either by the disappearance of some specific carbonaceous compound, or, more commonly, by the production of carbon dioxide or methane (the latter only under anaerobic conditions), and, finally, by the production of some intermediate products such as organic acids.

There are a number of bacterial transformations of sulfur in water, such as the assimilation of sulfur for cell structure, oxidation of hydrogen sulfide to sulfur and sulfuric acid, and the reduction of sulfate to hydrogen sulfide. The latter is the nightmare of stream sanitation. It is brought about under strictly anaerobic conditions in the absence of both molecular and combined oxygen in the form of nitrate and in the presence of organic hydrogen donors. The responsible organism is specific, is confined to a few species, and requires a low redox potential (-200 mv.). Such a condition exists in bottom deposits, and hydrogen sulfide is, therefore, generally associated with such deposits rather than with flowing water.

The bacteria in water can occur in three different situations: (1) free-floating, planktonic forms, in a drifting or swimming state, (2) attached forms, and (3) sedentary or benthic forms in the bottom sediments. These three states of life are not mutually exclusive. The drifting or swimming forms settle to the bottom, and those in the bottom sediments may be lifted up to the overlying water. At times free-floating forms find attachment, and attached growths in turn break off and may be found floating and eventually will form a part of the bottom deposit. In the free-floating state, they may be found either as individually dispersed cells or in association of groups of cells, or associated with other solid organic or inorganic particles.

In an attached state the aggregation of cells is larger, forming masses of growth visible to naked eye. They consist predominantly of one type of bacterium but incorporate in them some extraneous organic or inorganic debris as well as other microorganisms which can be considered as secondary

invaders. This type of growth is exemplified by typical slime growths in waters in which the predominant organism often is Sphaerotilus. This type of growth is easy to identify and evaluate, since the growths can be removed from their attachment and examined microscopically. They form long threads with the individual cells encased in a sheath and surrounded by a slime layer on the outside of the casing. The amount and rate of growth under a given natural or artificial condition can be evaluated by the submerged slide technique. In shallow streams these organisms play a major role in the stabilization of organic matter in polluted waters.

The bottom types of bacteria consist of those deposited from above as well as those actively growing under the conditions prevailing in this location. They are associated with large quantities of organic and inorganic deposits and ooze which are generally anaerobic.

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Paper of the Journal Series, N. J. Agricultural Experiment Station, Rutgers University, the State University of New Jersey, Department of Sanitation, New Brunswick, N. J.

How Furnish Affects Formation

LARDEN V. HOFFMAN

THE formation of stock on a cylinder machine has always been a rather nebulous property. Every papermaker has his own theories as to which stock will form best on his own machine, and these theories do not necessarily agree with those held by other papermakers. The accepted method of checking formation in board is still to inspect a sheet of board visually for any knotty or wild appearance of the top liner. The fallacy in this method of checking formation is that formation may easily be confused with other properties, such as smoothness, brightness, and coverage, or the amount of liner on the sheet.

The most common conception of how furnish affects formation is that formation is affected solely by the length of the fibers in the furnish. The length of fibers is, perhaps, the most important factor, but if this were the only criteria of formation, then all furnishes would form the same, given the proper treatment.

I do not believe that this is strictly true. All fibers in a solution will tend to come together and form flocs of fibers. This flocculation of fibers is one of the major causes of poor formation in a sheet of board. This is normally a reversible reaction, that is, these flocs may be made and destroyed several times during the papermaking process by the velocity and direction changes in the flow of stock. Certain fibers appear to form flocs more readily and break apart less readily than others. This characteristic makes for less uniformity in the board and hence poorer formation. Several theories have been advanced for this apparent desire or lack of desire for fibers flocculation. One theory has been suggested, that the type or amount of lignin remaining in the fibers may affect this chemical flocking. Also, certain chemical additives exert a great influence on this property.

To my knowledge there has been no effective or widely accepted method developed for demonstrating or measuring the quality of the formation of stock for paperboard, and it is not the purpose of this paper to propose such a method. However, until such a system or instrument is developed, any study of formation is more or less groping in the dark.

METHOD OF SAMPLING FORMATION

In an attempt to show how a change in furnish will affect the formation of a sheet of board, we have employed a system which demonstrates some basis for comparison of formation, although it will give no accurate measurement of formation. For this study we have taken various furnishes which were actually run on the 90-in. cylinder machine at the Wabash mill. This machine has eight counterflow vats. We have restricted this study to one cylinder of top liner furnish only, since this will most readily show formation changes Since this paper deals only with the effect of furnishes on formation, we must assume that all furnishes were prepared correctly and that each had the proper beating, refining, and jordaning time for the stock used. This is necessary so that we do not have to consider the effect of varying stock preparation and chemical additives on formation Although the preparation of the furnishes may not have produced perfect board, it was at least acceptable.

As each of these furnishes was sent to the paper machine, a liner scab was taken on the last top liner cylinder. All of the scabs were taken at the same place on the cylinder, about one foot in from the front side of the sheet. These liner scabs, as most of you know, are taken by means of placing a piece of tissue paper (approximately 4 by 7 in.) on the last liner cylinder so that it forms in the sheet between the final top liner layer and the balance of the sheet. This tissue must be placed very carefully so that it will not disturb the formation on the cylinder. At the end of the paper machine, the sample is cut out, the tissue is removed, resulting in a sample of the stock from the final top liner cylinder. For this study, all of the samples were taken from board of approximately the same caliper, and the liner samples in all cases were very close to 0.0025 in. thick. These samples were placed in glass slides and projected on a screen so that the formation characteristics could be studied and compared with those produced from other furnishes.

I realize that this method covers only a small portion of the actual sheet. However, in order to establish a trend of formation for the furnish, at least four scabs were taken from each grade run and three grade runs were studied to establish a representative sample for each furnish. As an additional check on formation, samples were taken using the same furnish on our other paper machine. While there was a different wire mark evident in the two machines, the same general pattern showed up for each type of furnish. It was found necessary to compare samples of equal caliper because a small change in caliper varied the projected formation pattern considerably.

One other defect in this system is that it relies on visual comparison which is, to say the least, very difficult to standardize as it introduces the factor of personal opinion into the study.

FURNISHES TESTED

The following furnishes were used as a basis for this study:

1. Canadian unbleached kraft pulp
2. Western semibleached kraft pulp
3. Western bleached kraft pulp
4. Southern semibleached kraft pulp
5. Southern bleached kraft pulp
6. Western bleached sulfite pulp
7. Southern bleached hardwood kraft pulp
8. Hard white envelope cutting (sulfate)
9. Tabulating cards (sulfite)

Nearly all board furnishes must necessarily be a compromise in an effort to meet the various and often conflicting requirements of the finished sheet. Thus, most furnishes are a mixture or blending of several types of fibers, both pulps and wastepapers.

For this study, all the furnishes used were composed of a single pulp or one type of wastepaper in order to give a better differentiation between the formation given by each stock.

This study only scratches the surface as far as the variety of furnishes used in the manufacture of board is concerned, but we have tried to evaluate a reasonable cross section. Because of the nature of this study, our furnishes were limited

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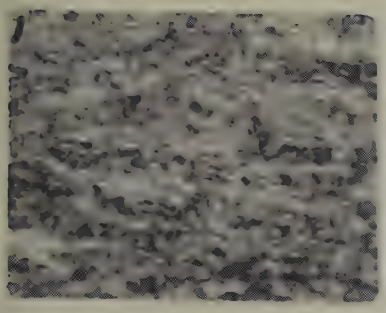

FIG. 1
CANADIAN UNBL. KRAFT

FIG. 2
WESTERN SEMI-BL KRAFT

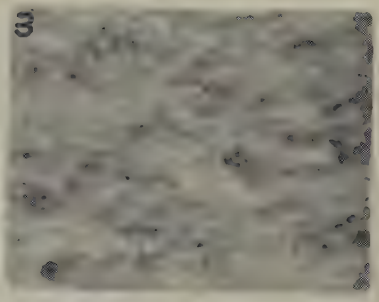

FIG. 3
WESTERN BLEACHED KRAFT

FIG. 4
SOUTHERN SEMI-BL. KRAFT

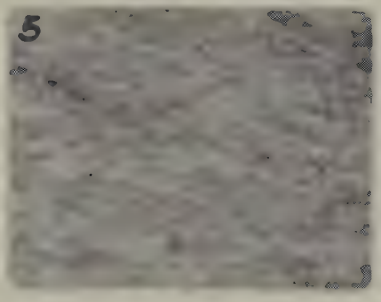

FIG. 5
SOUTHERN BLEACHED KRAFT

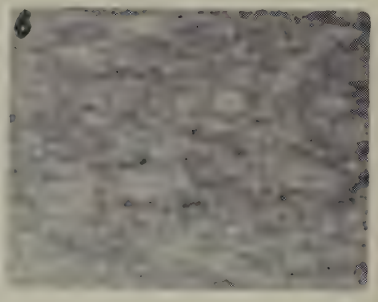

FIG. 6
WESTERN BL. SULPHITE

FIG. 7
SOUTHERN BLEACHED HARDWOOD

FIG. 8
HARD WHITE ENVELOPE CUTTINGS

FIG. 9
TABULATING CARDS

by the extent of our production grades. We did not have an opportunity to check many furnishes that appear interesting, although we do hope to consider these at a later date.

FORMATION COMPARISONS

Figure 1. *Canadian Unbleached Kraft Pulp.* This pulp is composed of jack pine and northern fir. These woods are not so long fibered or so strong as some of the western pulp woods. They produce one of the better forming unbleached kraft pulps. However, this formation is still poor compared with other furnishes tested.

Figure 2. *Western Semibleached Kraft Pulp.* This pulp is produced from western fir primarily, with some western hemlock, and possibly some Sitka spruce. This is one of the longest fibered pulps. It produces a sheet that is quite strong, but the large fibers make the sheet more porous and do not give the best finish. The formation of this furnish is one of the poorest tested.

Figure 3. *Western Bleached Kraft Pulp.* The bleaching process tends to break down the fibers slightly, thus giving a pulp not quite so strong as the semibleached or unbleached krafts, but with slightly better formation. The formation is still not very good as can be seen from the large dark and light areas in the photograph.

Figure 4. *Southern Semibleached Kraft Pulp.* This is one of the better forming softwood kraft pulps. It is produced from yellow pines, principally loblolly, longleaf, and shortleaf, and slash pines. These fibers are not quite so long as those of the western woods and they are slightly more dense. They produce a pulp that is somewhat weaker than the western krafts, but they tend to form better. This is illustrated by the size and number of the dark and light areas in the photograph.

Figure 5. *Southern Bleached Kraft Pulp.* This further illustrates the theory that the bleaching process tends to break down fiber length and to improve formation.

Figure 6. *Western Bleached Sulfite Pulp.* The woods from which this pulp is produced are mainly western pine, spruce, and silver fir. These are fairly long fibered woods, but the sulfite process reduces the fibers and the pulp forms quite well.

Figure 7. *Southern Bleached Hardwood Pulp.* This pulp is composed chiefly of the fibers from sweet and black gum and swamp bay. These woods have very short, dense fibers that do not tend to floc readily. They make up a pulp that has fairly poor qualities of strength or bender, but it forms quite well as can be seen by the fairly uniform appearance of the photograph.

Figure 8. *Hard White Envelope Cuttings.* This wastepaper furnish was originally a bleached sulfate sheet. Since this was the second time through the process, the stock produced was well hydrated, fairly short, and formed a very uniform sheet.

Figure 9. *Tabulating Cards.* The particular cards used in this furnish are mainly from a semibleached sulfite sheet. As they have already been through the papermaking process, they form a short, easily cut furnish. This furnish forms quite well and makes a very uniform sheet. In fact, this was the best forming stock tested.

CONCLUSIONS

From a study of the photographs, I would place the furnishes tested in the following order for formation.

1. The best formation of all the furnishes tested in this study was obtained from the tabulating cards. Although we were not able to determine the exact origin of these cards, the fact that they were a sulfite and had been processed once, would indicate that the formation should be good.

2. The next best forming furnish would logically be the hard white envelope cuttings because of the fact that they had also been processed once, although they were originally from a sulfate sheet of a slightly longer fibered stock than the tabulating cards. This observation was confirmed by our study.

3. The best forming pulp tested, in my opinion, was the bleached hardwood. The comparatively short, dense fibers did not seem to floc or tangle very readily, and, therefore they tended to form a more uniform fiber mat.

4 & 5. The next place in this formation rating is open to considerable debate, and, because of this, we made more trials with these two pulps than with any of the others. I believe that it is almost a toss-up between the southern bleached kraft and the western bleached sulfite. On the several runs that were made, it was very difficult to distinguish between the two as far as formation is concerned. In actual use, we have preferred the bleached sulfite for our lighter calipered board.

6. The formation of this pulp was still fairly good compared with other softwood krafts.

7. The western bleached kraft furnish was the poorest bleached furnish tested. Its long fibers and large flocs were quite apparent in the photograph.

8. The western semibleached kraft showed the open formation that you might predict from its component fibers.

9. The Canadian unbleached kraft, while showing the worst formation of any of the furnishes tested, formed quite well for an unbleached kraft pulp.

There are two final conclusions that may be drawn from this study.

First: Formation on a cylinder machine may be greatly changed by the furnish used. Second: And far more important—that there is a definite need for an effective means of evaluating formation. When such a means is developed, further study should be initiated in this field to enable the papermaker to predict accurately, in advance, which stocks will give him the best formation possible, commensurate with the final specifications of the board to be produced.

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New Aluminum Pigment Systems for Water-Base Paper Coating Application

A. F. KNOLL

Two new aluminum pigment preparations for water dispersed coating applications were developed for use in water base paints and show promise for use in paper coating applications also. Our belief in this respect is confirmed by two of the nation's largest producers of latex emulsions, who have done considerable work in developing latex coating formulas for paper using one of these pigment preparations. They are prepared to cooperate in the application of their findings to paper finishing.

As you all know, aluminum pigments are not new to the paper industry. A large quantity of aluminum powder is used each year in the production of gift wrappings, heat reflecting paper, and in boxboard coating. Aluminum pigments are used also in lacquer coating and in printing ink in organic vehicles. Aluminum pigment or "silver," as it is commonly identified, can do much to enhance the eye appeal of cartons and packaging, which is a major objective in modern mechandizing.

The pigment systems which we will discuss here are designed for use in water-base vehicles only. The first system permits the preparation of water-base coatings of long storage life. In latex vehicles, coatings of high reflectance and good

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adhesion can be obtained. Also, the system can be used to obtain colored metallescent and texture effects in one coating application. A novel hammer finish has been developed using this pigment system which can be applied to paper either by spraying or by knife coating. Its application by the air blade has not been tried as yet but appears practical.

The other system yields coatings of high total reflectance and excellent adhesion. It can be calendered to simulate the appearance of foil. Protective paints made from it should prove of interest to maintenance engineers as they yield film of high reflectance and can be applied to a damp surface.

Aluminum pigments have been available for 50 or 60 years. For about half this time, because of the hazards entailed in the older methods of manufacture, aluminum pigments were limited to a few coarse grades and were relatively high in price. Since the invention and development of the wet milling process, about 30 years ago by E. J. Hall, founder of Metals Disintegrating Co., aluminum pigments have become available in many grades and varieties and at a lower price. By carrying out the flaking operation in a ball mill using a mineral spirits medium, the explosion hazard attending the obsolete dry stamping methods has been eliminated.

The Hall process pigments are available in the leafing and nonleafing types. The leafing type is formed by the use of stearic acid as a lubricant in the milling operation. During milling an oriented solvent insoluble aluminum basic stearate film is formed on the surface of the aluminum flakes which permits the flake particles to leaf or float in vehicles of proper surface tension characteristics. The nonleafing type of aluminum pigment is formed by the use of an unsaturated fatty acid or equivalent material as a lubricant, or by the removal from or disorientation of the stearate film on the particles of the leafing type.

Both types are made in several grades of particle size and to yield a variety of surface finishes. They are marketed either as pastes in a hydrocarbon thinner or as dry powders.

The leafing type is used mainly to obtain the well-known silvery surfaced aluminum paints used in exterior surface protection and in interior and industrial decorative finishing. The nonleafing type is used mainly in obtaining metallic enamels, metallescent and texture finishes.

The leafing and the nonleafing types of aluminum paste can be had in varieties that are readily dispersible in lacquers and other fast drying vehicles and find some use in coating paper. The standard lining grade of nonleafing aluminum powder has for a number of years been used in greater quantity in casein size for coating paper, boxboard, etc., as mentioned before. This pigment is usually made with an unsaturated fatty acid as a lubricant. This type of lubricant makes for easier dispersion of the aluminum pigment in water. Past attempts to use the leafing type of aluminum powder pigment in a water-base vehicle have not been successful. This type of pigment carries a stearate film which usually makes for difficult dispersion and poor adhesion of the dried aluminum coating to the paper. One of the pigments which we will discuss now is a water dispersible hydrocarbon thinned paste pigment of the leafing type. This entirely new pigment yields coatings on paper which have excellent adherence and minimum rub-off characteristics. Also, the use of a leafing pigment permits the development of coatings of higher reflectance than that given by the nonleafing type.

The standard lining grade of nonleafing powder is probably the most widely used aluminum pigment in casein coating applications. This grade has sufficiently large particle size to yield satisfactory reflectance in coating applications and at the same time it has satisfactory hiding and covering capacity. This powder is denoted as 100 mesh unpolished, or litho, which in our industry means nonleafing. About 97% of it passes a 325-mesh screen (44 microns). Its covering capacity on water is about 12,000 sq. cm. per g., which is equivalent to an average flake thickness of 0.3 to 0.4 μ. Its grease content is less than 1%. The low grease content and its type promotes water dispersibility. In typical applications this powder is mixed with a casein size, latex, or similar adhesive dispersion for paper coating.

A characteristic property of aluminum in finely divided form is its tendency to react and produce hydrogen gas when mixed with water. The rate of reaction is increased by acid and alkali and by the use of wetting agents. This characteristic has been acknowledged by pigment producers and recognized as a limitation in the use of these pigments by coating formulators for many years. Formulating chemists have recognized this by specifying that aluminum-water base coatings be job-mixed for an expected short pot life of a few hours or so.

We now propose to describe to you a recently patented process which reduces this reactivity to a point which permits storage of aluminum-water base coatings for months and longer. Typical aluminum coatings made in accord with the procedure to be described and using a variety of vehicles as, for example, acrylic, polyvinyl acetate, butadiene-styrene, casein, alkyd hydrocarbon resin and copolymer dispersions, have been stored for months without suffering any gross degradation of reflectivity, coverage, or stability. As a typical example, a polyvinyl-acetate latex dispersion pigmented with a stabilized aluminum paste yileded a film on paper which on drying showed a total reflectance of 60% (combined specular and diffuse). After 1 year storage the same coating remixed easily with unchanged smoothness and consistency to yield a coating with a reflectance of 58%.

If an aluminum powder pigment of either leafing or nonleafing type is pretreated with a nonpolymeric inorganic phosphate, the pigment's activity toward water is reduced almost completely. Although there are several alternative procedures and materials, the preferred one is to mix the powder pigment with a solution of a water-soluble phosphate as, for example: diammonium hydrogen phosphate ($(NH_4)_2HPO_4$), ammonium dihydrogen phosphate ($NH_4H_2PO_4$) or phosphoric acid (H_3PO_4).

The use of a small amount of wetting agent promotes the reaction between the pigment and the phosphate stabilizer which is a necessary part of the process.

A typical procedure is as follows: Dissolve 3 parts of ammonium dihydrogen phosphate ($NH_4H_2PO_4$) in 100 parts of water. Add 0.5 parts of Triton X-100, or equivalent surfactant, and stir to insure complete dispersion of the surfactant. A stirring time of 15 min. may be necessary to insure complete dispersion. Mix in 50 parts of MD 3100 or 2100 aluminum powder. This mixing should be done carefully and the stirring should be slow to prevent dusting, which is a hazard. Hand-mixing with a wide bladed spatula on a laboratory scale, or a pony type mixer at about 60 r.p.m. on a plant scale is suggested. After the powder is thoroughly dispersed and wet out, permit the mixture to stand for 48 hr. During this time some gassing may be evident as reaction between the phosphate and aluminum takes place. This reaction appears to be a necessary part of the stabilization procedure. During this time the phosphate becomes a part of the aluminum pigment particles as an insoluble coating. If the treated pigment is washed with water shortly after mixing the major part of the phosphate can be removed. However, with longer time contact the phosphate becomes insoluble in water and cannot be removed by simple washing. It appears that the phosphate salts used cause the formation of a barrier around the aluminum pigment particles. This barrier is practically impermeable to water. We have evidence that this barrier is a gelatinous form of aluminum phosphate.

The aluminum paste pigment, stabilized as prepared above can then be mixed with the adhesive or other vehicle. At the present time it is suggested that the adhesive or other vehicle be adjusted to a pH within the range of 3.0 to 8.5 before addition of the stabilized pigment paste. Maximum stability of the final coating dispersion is obtained in this range of hydrogen ion activity.

We must emphasize that most commercial adhesive and vehicle formulations contain numerous additives in addition to the film former and water. These include leveling agents, thickeners, dispersants, antifreeze additives, extenders, fungicides, bactericides, inorganic salts, sequestering agents, etc. Any chemical which impairs or destroys the integrity of the phosphate barrier coat can make the stabilizing system unworkable. Chemicals which form soluble complex ions with aluminum as, for example, hydroxyacids and pyrophosphates or high acid and alkali concentrations which dissolve the phosphate will remove the protecting barrier. Mercury compounds and compounds of other metals which may form active couples with aluminum metal should not be introduced into the formulation.

Both the nonleafing and leafing type pigments can be used to obtain a variety of natural aluminum and colored metallic effects. Most water dispersed colors are compatible with the system, the only exception we have run into so far are iron oxide colors. Texture finishes similar to the hammer finishes have been developed by one of the prominent latex producers.

Our development has been of considerable interest to manufacturers of latices and resin emulsions. They have published technical bulletins with numerous formulations combining this aluminum stabilizing system with their particular resins. Although most of the information applies to the protective coatings field, the formulations used in this field are quite similar to those used in paper coating so that they can be used as a basis for work in your field. Several of these technical bulletins give specific information on paper coating applications.

It must also be emphasized that these aqueous aluminum coatings still evolve hydrogen gas at a very slow rate and will continue to do so during storage. It is, therefore, not advisable to store such in sealed vessels. Storage containers should be properly vented. Vent-type drum bungs are available.

The development described above starts with an aluminum powder pigment which the user disperses and stabilizes for his own use.

The second new development which we will describe is a water emulsifiable aluminum paste pigment. The pigment is a typical leafing grade of aluminum paste containing hydrocarbon thinner plus surfactants which permit ready emulsification of the paste into latex or resin water-base vehicles.

Water emulsifiable aluminum pastes are not new. Several have been on the market for a number of years. These pastes, however, had one weakness. The type of surfactant used permitted the easy rewetting and removal of the coating after it had been applied to the surface and dried.

The pigment presented here and designated as MD 9835 aluminum paste permits the development of an aluminum coating which is substantially water resistant. This pigment is designed particularly for absorbent surfaces. The dispersions can be diluted with large quantities of water which makes them particularly promising for consideration by the paper coating industry. The undiluted versions can find use as a paint in protective and decorative coatings, particularly on damp surfaces and in wet atmospheres, which feature should be of interest to paper mill maintenance people. Of particular note is the high degree of brightness obtainable with some of the formulations. Reflectances of 75 to 80% have been obtained.

In a typical preparation for coating paper the MD 9835 aluminum paste is reduced with a solvent resin solution and this mixture is then stirred into a latex or similar water dispersion properly modified. This mixture can then be applied to paper in the usual way and calendered. Brightness equal to a total reflectance of 78% and a 60° gloss of 150 mils are obtained readily.

U. S. patent 2,858,230 has been issued on the first development. Aluminum pigments for use in this system are commercially available. Technical literature giving formulas, etc., will be sent to those interested. The second development has patents pending. Experimental samples and suggested formulas can be made available.

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Controlled Air Systems with Enclosed Hoods

GEORGE F. SCHUNING

Air is an intangible material which can be obtained in any amounts apparently without cost and, therefore, its economic importance as a papermaking material is easily overlooked. To stress the importance of air in the manufacture of paper we need only point out that to carry away the moisture evaporated in the drying of 1 ton of paper approximately 60 tons of air is used with an open canopy-type hood. In a mill manufacturing 200 tons per day of paper this results in approximately 12,000 tons of air every 24 hr. Converting this into cubic feet of standard air we arrive at a figure of 324,000,000 cu. ft. of air per day. All of this air must necessarily be heated up from outside conditions in order to properly absorb the water vapors and convey this water to atmosphere. To properly handle this weight of air requires large amounts of power and heat.

GENERAL DISCUSSION

How do we determine the amount of air which is necessary in the drying of paper? The starting point is to establish the amount of water which is to be evaporated from the sheet during the drying process, then the psychrometric conditions at the mill location are determined arriving at the amount of moisture in the air which we are going to use. The physical shape and size of the particular hood for the collection of the vapors will then determine the amount of water that each cubic foot of air can absorb. With an open-type hood the exhaust volume must necessarily be appreciable in order to prevent diffusion of vapors to the machine room and also to keep the dewpoint temperatures sufficiently low so as to prevent condensation on the interior surfaces of the hood. Once the exhaust volume has been established, we must also face the reality that this volume of air must also be supplied to the machine room to arrive at an over-all optimum mill air balance. In other words, the absence of a positive supply to the machine room results in a situation analogous to attempting to suck air from a bottle. This cannot be done unless air is properly supplied. If a mill is operating under an appreciable vacuum, the static pressure against which the exhaust fans must operate is increased, the horsepowers are increased, and the exhaust volumes markedly reduced, resulting in spilling of vapors to the machine room and condensation forming on the ceiling and walls. This results in poor machine room working conditions with seepage of cold air through all cracks and crevices and extreme drafts occurring when doors and windows are open.

Inasmuch as the usage of air is actually an expensive item, it is important that we make every pound of air handled do its maximum job in carrying away moisture from the machine. We have established that one of the basic items determining the amount of air required is the physical shape and size of the enclosure over the machine. This type of approach to the problem has resulted in the modern totally enclosed hood which permits the use of a minimum exhaust volume to contain the moisture evaporated. It has been found that with an enclosed hood approximately 50% of the exhaust volume

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previously required for an open hood will do the job. Not only does this reduce the exhaust volume by half but the actual amount of air heated and delivered to the machine room also becomes one-half the former quantity.

Once the exhaust volume has been established and total make-up requirements calculated, the next question is where should the supply air be delivered for maximum utilization. Naturally, the air should be delivered to points which will result in the greatest benefit both to production and to comfort of operating personnel. The area of supply which will definitely add to the efficiency of drying is to deliver the air directly to the drying process through a felt supply system, or through a vapor absorption system on a machine which does not have drier felts. This warm, dry air, if properly delivered, will materially increase drying both by impingement of the air directly on the felt or paper as well as creating conditions about the machine conducive to improved drying. Although it does not contribute to the machine room air balance, the use of a Grewin system then comes into play and, as the warm air passes up over the machine, the high velocity jets will induce this air, purging the pockets formed by the travel of the felts and paper. A second area for use of outside air is to deliver warm air to the roof which has the twofold purpose of reducing the tendency of formation of condensate on building members as well as to provide heat for the machine room. This system then is used both for comfort of operating personnel and for reduction of condensation dripping into the machine or on finished paper which in effect will increase machine efficiency due to reduction in loss of paper as well as materially reducing building maintenance. Differential temperature control is used for roof heating and ventilating so that as the outdoor temperature decreases, the supply air temperature will automatically increase, taking care of the increased building heat load during cold weather.

A third use for supply air is through year-around comfort ventilation units. These can be located at various points in the machine room where there is a concentration of operating personnel. They serve the purpose of warming these areas during cold weather and providing fresh outside air during summer weather. Removable floor-type man-cooler units are used to advantage in this type of system as these can be located at various points throughout the machine room operating floor and can be easily removed during periods of maintenance or machine changes. We have now supplied air to the specific areas on the machine and in the machine room which can most effectively utilize make-up air. With an enclosed hood installation, there is usually no necessity for additional supply air. However, with a properly designed open type installation there is usually still a considerable imbalance due to the large quantity of air which must be exhausted from the machine. Additional large make-up units are necessary to supply tempered outside air and these can be located at appropriate points such as at the ends of the basement and at the ends of the machine room, delivering tempered air during the winter and cool air during the summer to prevent heat and humidity build-up and stagnation at the ends of the building.

As you all know, modern paper machines have continually been increasing in speed and width resulting in high production units which necessitate proportionately larger and larger exhaust and supply volumes. The proper and most efficient use of air has become most important and more critical as machines have gone up in speeds and width. The large exhaust volumes required with open hoods on the wide machines, especially making lightweight papers, has caused drying problems due to the increased in-draft resulting in edges running drier and centers running wetter. There was a definite need for an improved type hooding arrangement which resulted in considerable research and development work evolving in the insulated panel, totally enclosed hood installation (see Figs. 1 and 2).

Fig. 1. Sonoco's 140-in. 62 drier paper machine prior to installation of totally enclosed hood

With this type enclosure it becomes possible to more postively control the psychrometric condition of the air to and from the drier section of the machine. No longer do we have to worry about exhausting sufficient air to prevent spilling into the machine room as the entire drier section, including the basement, is completely enclosed. Also due to the insulated type of construction exhaust temperature and absolute humidity can be materially increased without reducing the relative humidity or moisture carrying capacity of the exhaust vapors.

Due to more complete control of air flows within the enclosure, the psychrometric conditions can be varied and controlled at the point most conducive to efficient operation. Due to the elevated dry bulb and web bulb temperatures variation in atmospheric conditions have little or no effect on the drying operation, whereas with an ordinary open-type hood, especially in some areas, changes in the weather have had a detrimental effect on the drying operation. Because of the insultated panel-type construction, the radiation from the driers to the room is considerably reduced. The humidity in the room is also kept to a minimum due to reduction in the possibility of vapor spilling or diffusing from the hood which almost always takes place with an open hood at various points. The enclosed installation also prevents cross drafts which in some cases on open-type hoods actually cause a marked variation in drying characteristics across the width of the machine. Due to the reduction in radiation to the

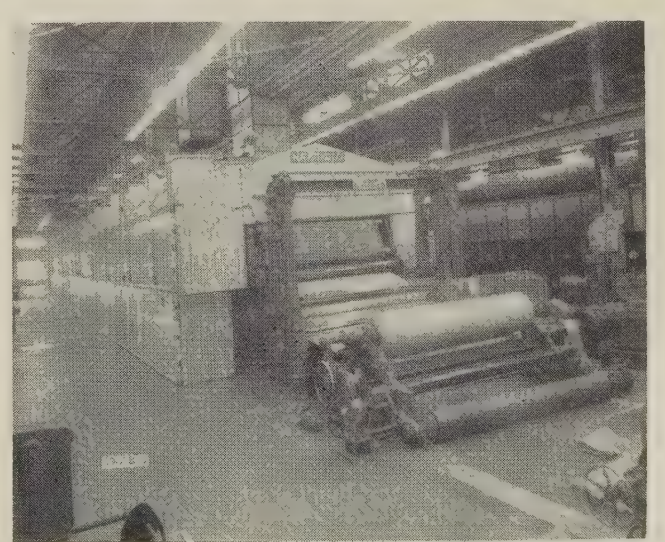
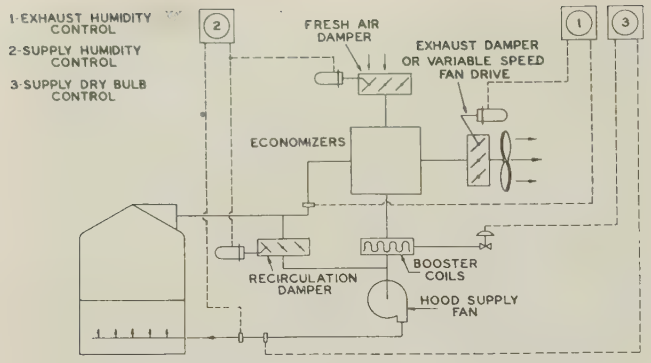


Fig. 2. Same paper machine as it exists today, with totally enclosed hood



ENCLOSED HOOD ATMOSPHERIC CONTROL SYSTEM

Fig. 3

machine room and because of improved conditions for drying, the amount of steam required for evaporation per pound of water is considerably reduced. In other words, the drying rate on a given machine is increased.

ENCLOSED HOOD ECONOMIES

The only way the exact savings can be determined is to study an existing paper machine with open hood-type systems and then convert to a modern totally enclosed installation. This has been done in several instances with large savings in steam, increased production rates, and marked improvement in machine room comfort conditions. Following are the results of an installation which was carefully studied both before and after the installation of an enclosed hood. The steam consumption on the drier section per pound of water evaporated was reduced from 1.635 to 1.305 lb. steam per lb. of water evaporated. This represents a 20% reduction of steam to the drier section for the same production rate.

In this same study it was observed that the drying rate, which is the pounds of water evaporated per square foot of drier surface per hour, was increased on one machine 18% and on a second machine 21.1%.

It has also been found that the air necessary to carry the moisture from the machine with a closed hood is approximately 50% of that which would be required for ideal open hood operation.

A study was also made and it was revealed that the dry bulb and wet bulb temperature on the operating floor throughout the length of the machine room were more uniform and appreciably improved. In actual tests the amount of moisture in the room throughout the operating areas was reduced by 42½%.

It should be pointed out that with the enclosed hood and its higher exhaust temperatures, the economic return with the use of Briner economizers is appreciably increased and the peak steam demand during the cold winter weather considerably reduced. With the higher exhaust temperatures prevailing, the use of economizers becomes economically profitable even in the most southern areas of our country. The heating of water following the economizers is also an area where considerable amount of heat otherwise lost can be reclaimed and put to use.

CONTROLLED PSYCHROMETRIC CONDITIONS

We mentioned that with the use of an enclosed hood it was possible to control the psychrometric conditions of both the supply and exhaust air from the machine. The control of the exhaust is desirable to enable handling only the amount of air which is required to remove the water evaporated from the sheet. In other words, if the amount of drying on the machine varies, the amount of exhaust should vary in direct proportion. Also should the weather change resulting in

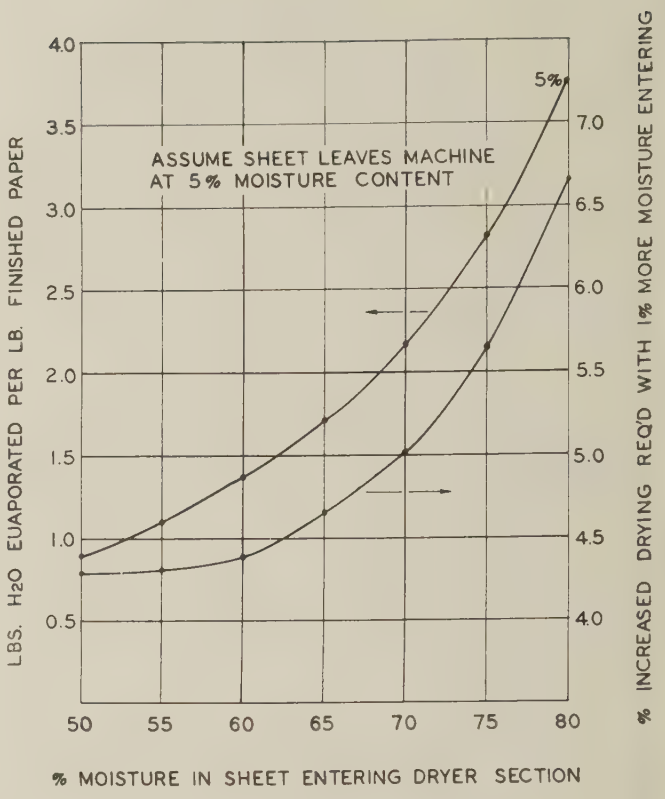


Fig. 4

drier or more moist air entering the machine, the exhaust volume should again be automatically reduced or increased proportionately.

It is important also to consider the possibility of controlling the air supplied to the machine. If the dry bulb and wet bulb temperatures of this air can be controlled accurately, the effect of outdoor weather changes will not affect the drying process and psychrometric conditions most conducive to proper drying can be maintained.

The control of the exhaust is accomplished by use of a wet bulb or dewpoint controller regulating the position of dampers preceding the exhaust fans. It is also possible to regulate the speed of the exhaust fans by using a variable speed drive. The humidity of the air entering the enclosure is controlled by proportioning the amount of fresh air and amount of recirculated air from the exhaust. The dry bulb temperature of the supply air is controlled by the amount of steam metered to the booster coils (see Fig. 3).

EFFECT ON DRYING OF SHEET MOISTURE CONTENT

We all realize that the drier the sheet entering the drier section the less water will have to be evaporated on the machine. We would like to point out that at various moisture contents entering the machine a 1% increase in moisture can result in anywhere from approximately 4 to 6% increased drying demand. In other words, even though we feel that possibly a 1% increase in moisture at the wet end may not be significant, if should be point out that if the paper is entering the machine at 70% and this were to increase to 71%, approximately 5% more drying would be required in the drier section. It is therefore important that the moisture content of the sheet entering the drier section be as low as possible and uniform as small percentage variations at the wet end result in larger variations in demand across the width of the machine once the sheet reaches the driers (see Fig. 4).

Even though the moisture content entering the drier section is uniform across the width it must also be remembered that the basis weight should be uniform. In other words, with a 1% variation in basis weight it becomes necessary to evaporate 1% more moisture. Even though moisture tests may be

uniform in themselves a basis weight traverse is also of importance.

FACTORS AFFECTING UNIFORMITY OF DRYING

Naturally there are many factors which contribute to nonuniformity of drying and many of these result in conditions which are practically impossible to correct by the use of air. First attempts in correcting nonuniformity should be centered at the wet end of the machine. As pointed out, variation in moisture content and basis weight entering the drier section are the first things to investigate. Also factors such as variation in density or freeness across the width may not be evident in moisture samples at the wet end but after the sheet has passed through several driers, the wet streak will show up and becomes extremely difficult to correct. If the caliper of the sheet varies as it leaves the press section, the high points in caliper are compressed through smoothing presses and breaker stacks, and the removal of moisture will become more difficult at these particular points. Also such things as drier surface temperatures, drainage systems, condition of drier felts, felt tensions across the width of the machine, and other things such as machine alignment, or drier run-out should be checked.

CORRECTING NONUNIFORMITY WITH AIR

However, after the preceding items have been thoroughly investigated and found to be satisfactory, there are still things that can be done with use of air to possibly correct nonuniformity of drying. The most effective type of correction can be employed on a machine which does not use drier felts and on this type machine a vapor absorption system can be installed with nozzle pipes designed for delivering more air to the points across the width which are running wet. Considerable development work is being done to develop adjustable nozzle pipes, however, several methods are currently being employed. One unit is the Verwayen nozzle pipe which utilizes a pipe within a pipe and by rotation of the outer pipe the pattern of air delivery across the width of the machine can be varied. Another type nozzle pipe which has been used successfully permits the adjustment of air flow from each nozzle over the length of the pipe. Each nozzle has a separate blastgate, valve, or damper so that air flow can be adjusted for maximum flow at points normally running wettest. Normally the great majority of machines run wettest in the center with the back and front sides running drier. A common type nozzle pipe which is effective for this condition is the center-fed pipe with dampers to regulate the portion of air flowing to the front or back of the machine so that all air can be concentrated at the center of the machine with varying amounts then delivered to the front or back sides (see Fig. 5).

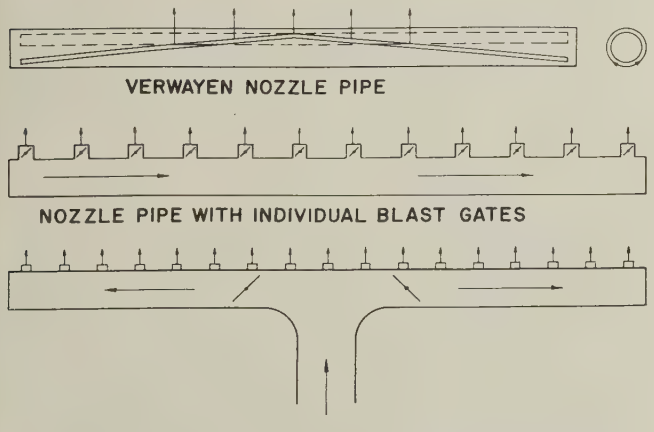
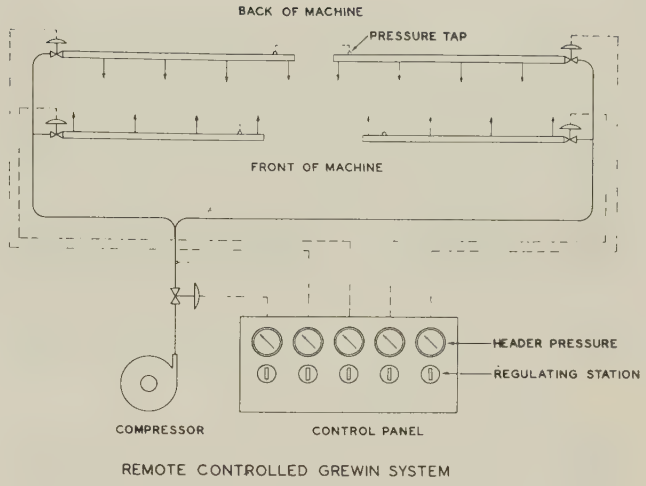


Fig. 5



REMOTE CONTROLLED GREWIN SYSTEM

Fig. 6

These various type nozzle pipes can be employed in either a vapor absorption type system, blowing directly on the sheet or they can be utilized in a felt drying system on a machine using drier felts. However, to obtain any correction in nonuniformity of drying by use of air delivered to the felts it is important that the felts run slightly on the damp side. If the felts are overdried it is naturally impossible to do any correction by use of air. It is, therefore, important that the temperature of the felt driers be controlled separately in order to obtain this flexibility.

On a machine with drier felts a high velocity Grewin system can be utilized to reduce nonuniformity and this is most effectively done by sectionalizing the Grewin system with a series of valves in the longitudinal headers on the machine. Normally each section of the machine will have a separate longitudinal header both front and rear with a remote controlled valve regulating the pressure in each header. It is desirable with this type system to have a remote control panel upon which is mounted the control regulators for each air valve together with remote pressure indicators indicating the air pressure in each header. It is also desirable that a control valve be installed at the discharge of the main supply blower and again a remote pressure gage indicating the pressure existing for the entire system. Several of these type systems have been installed and are operating successfully (see Fig. 6).

The newest and perhaps the most revolutionary method which has been developed at this time is the SP, or sectionalized performance high velocity drier. This unit employs the principle of high impingement velocity at the sheet coupled with the flexibility of varying the velocity and volume

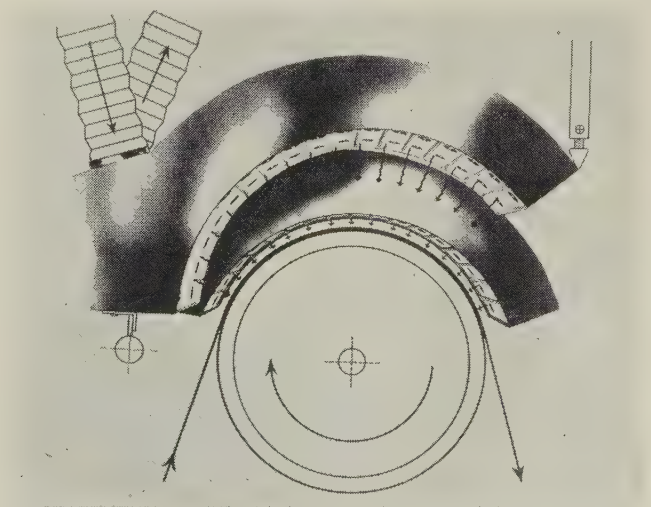


Fig. 7. Sectionalized performance high velocity drier

across the width of the machine. This unit consists of a series of drier heads located across the width of machine and each individual head has its own volume control so that impingement velocity at the sheet can be varied and also the distance of each drier head from the sheet can be adjusted resulting in maximum flexibility of performance. The position of the drier heads together with the pressure existing in each head is remotely controlled from a panel board by the operator. Coupling this type system with moisture indicating equipment will give the operator an immediate indication of the moisture content of the sheet at the reel permitting rapid adjustment to overcome nonuniformity of drying (see Fig. 7).

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Presented at the 44th Annual Meeting of the Technical Association of the Pulp and Paper Industry, Feb. 23–26, 1959.

A Study of the Dependency of Pulp Yields Upon Method of Determination

MERLE J. SHOWALTER
and
DAVID A. FEIGLEY, JR.

PROBABLY one of the most publicized aspects of semichemical pulping has been the report of high yields and the promise of very attractive efficiencies in the utilization of wood in the paper industry. A survey of the literature in this field shows that yields of 90% are commonly reported, a prospect that must be quite impressive to those experienced in the older, conventional pulping processes (*1–7*). However, recent results in this laboratory have led us to question the method of pulp yield determination in these published reports.

The question seems to boil down to a matter of definition. Should we define yield as the ratio of dry wood substance coming out of the pulping process to that in the logs, or as the ratio of wood substance obtained in the finished paper to that in the logs? It would seem obvious that the latter is the only logical and significant consideration.

Finding no standard method of yield determination recommended by TAPPI or any other agency, we naturally devised one of our own. Substantially this method determines the weight ratio of dry pulp obtained after digesting, defibering, and refining, to the original weight of dry wood. Fiber loss during these operations was negligible due to the arrangement of our pilot plant equipment, which is described below. The significant point is that the fiber was *washed* completely as it traveled from one operation to another until it was finally collected as a dilute slurry in a calibrated storage chest where the dry fiber weight was determined by measuring volume and consistency.

After developing some procedures that yielded pulps of obvious value from a variety of hardwoods, we proceeded to determine yields by what we have come to call the "consistency" method. Based on what we had read and heard, we anticipated yields of 85 to 90%, but to our dismay only realized results between 65 to 75%. This led us to re-examine the whole situation from the point of view of the relationship between method of yield determination and results obtained.

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As far as we can determine from reading and talking to other people interested in the field, the tendency is to determine yield by weighing the cooked and defibered product immediately after disintegration with a disk refiner. Since this type of disintegration usually involves little or no water, it is really the equivalent of weighing the chips immediately before and after the digestion cycle, thus including in the yield figure most or all of the water solubles produced during digestion. These water solubles would, of course, be lost during the papermaking operation.

As our experimental work soon showed, weighing chips immediately after digestion without defibering, refining and, in essence, washing by diluting to papermaking consistencies, gave us results in line with those apparently widely reported in the trade. We will refer to this procedure as the "dry weight" method. Essentially our data consist of a comparison of yields as determined by the two methods mentioned for: (1) straight steam cooks, (2) 2-hr. caustic soda steeps at room temperature and atmospheric pressure, and (3) 20-min. caustic soda steeps at room temperature and elevated pressure.

Aside from demonstrating the dependency of yield results on the method used, the main purpose of this paper is to suggest to the industry in general, and to TAPPI in particular, that some effort be made to standardize the method of determining yields, particularly as applied to semichemical pulping.

THE WOOD

Four-foot logs of aspen, soft maple, yellow birch, and wild cherry were handpeeled before chipping in an Asplund chipper. Random sized chips were used in the experiments. Their average dimensions were $^3/_4$ in. long in the grain direction, $1^1/_8$ in. wide, and $^3/_{32}$ in. thick. Chips were sampled for moisture content during the chipping. Cherry and maple had a moisture content of about 27%; approximate moisture contents of birch and aspen were 32 and 41%, respectively. The amount of green wood used for an experiment was 65 to 75 lb.

TREATMENT OF THE WOOD

1. Straight Steam Cooks. The steam cooking was conducted in a 10 cu. ft. stainless steel digester rotated at $^1/_2$ r.p.m. Chips were cooked for 5 min. at 150 p.s.i. Direct steam cooking was used, and the digester was preheated to 370°F. before charging. A time interval of slightly more than 4 min. at atmospheric pressure and high temperature was necessary in order to connect the digester prior to blowing down.

2. Two-Hour Caustic Soda Steeps at Room Temperature and Atmospheric Pressure. Aspen chips were soaked in a 2.4% NaOH solution with a liquor-to-wood ratio of 5 to 1.

3. Twenty-Minute Caustic Soda Steeps at Room Temperature and Elevated Pressure. Chips were soaked in a 5% NaOH solution in the rotating digester at 95 p.s.i. air pressure.

METHODS OF YIELD DETERMINATION

"Dry Weight" Method. Steam cooked chips were put into several large pans and dried to constant weight at 200°F. Cold caustic treated chips were washed before placing in pans and drying.

Calculation:

$$\frac{\text{Weight of treated chips (moisture-free)}}{\text{Weight of chips before treatment (moisture-free)}} \times 100 = \% \text{ yield}$$

"Consistency" Method. All of the treated chips were fiberized in a Bauer 24-in. double disk refiner. The pulp was pumped into a tank and diluted to 900 gal., which made a consistency of about $^1/_2$ of 1%. The slurry was sampled, and 1000 ml. was filtered through a Buchner funnel. The fiber retained on the filter paper was dried and weighed.

Table I. Yields Obtained from Steam Cooking

Method	% Pulp yield			
	Aspen	Maple	Yellow birch	Cherry
Dry weight	91.2	94.7	91.7	92.2
Consistency	83.1	82.6	68.6	69.8

Calculation:

From handbook:

900 gal. = 3,406,860 ml.

Using 1000 ml. slurry sample:

$$3406.86 \times \frac{\text{Dry weight of fiber retained on filter paper (g.)}}{454} = \text{lb. of wood (moisture-free) in tank}$$

$$\frac{\text{Pounds of wood (moisture-free) in tank}}{\text{Weight of chips before treatment (moisture-free)}} \times 100 = \% \text{ yield}$$

DISCUSSION OF RESULTS

All steam cooks were made under as nearly identical conditions as possible. In Table I it will be noted a high yield was obtained for all species when the dry weight method was used. Yields were 8 to 23% lower when the consistency method was used, and varied according to the specie. This variation is probably due to different amounts of water solubles produced during the cook.

Table II. Conditions and Yield Results of 2-Hr. Treatment of Aspen Chips with Sodium Hydroxide

Yield method	Treatment temperature, °C.	Caustic consumed		Pulp yield, %
		% of caustic charged	% of moisture-free wood	
Dry weight	25°	53.2	6.38	89.4
Consistency	25°	55.6	6.67	76.3

In Table II results of yields are reported on aspen chips treated for two hours at room temperature and atmospheric pressure in a 2.4% NaOH solution. Two identical steeps were made and the yields determined by the different methods. The yield for the consistency method was about 13% lower than for the dry weight method.

Table III. Yield Results of 20-min. at 95 p.s.i. Room Temperature–Caustic Soda Steeps

Method	% Pulp yield			
	Aspen	Maple	Yellow birch	Cherry
Dry weight	91.1	...	92.2	90.3
Consistency	77.2	76.4	64.4	73.9

In Table III results of yields are reported on identical steeps on hardwoods made with a 5% NaOH solution. The chips were immersed in the liquor for 20 min. at 95 p.s.i. air pressure and room temperature. A 17 to 28% higher yield was obtained by the dry weight method.

CONCLUSION

Yields were obtained which varied considerably, depending upon the method of determination. A standard method for determining yields is clearly needed, and it is suggested that the method be one in which water-soluble material is taken into consideration. Thus the method will be practical from the papermaker's standpoint.

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Paper Modification with Neoprene Type 400

C. H. GELBERT

THE use of neoprene latex as a saturant in the preparation of masking tape base, gaskets, shoe board, and imitation leather base was first described in 1948 (*1*). Subsequent publications disclosed the use of neoprene latex as a beater additive (*2,3,4*). The primary functions of neoprene are to provide an elastomeric binder to improve the internal bond strength of the paper and to protect the fiber-to-fiber bonds and the fibers themselves from the deteriorating influences of heat, water, chemicals, and other degradative forces.

Neoprene Latex Type 400 is the result of an extensive research effort to develop a neoprene latex that could be used by the paper industry with little or no additional compounding. Compared to other neoprene latices, Type 400 has superior polymer stability, lower wet and dry tack, and higher cohesive and adhesive strength.

GENERAL DESCRIPTION

Neoprene Latex Type 400 is an anionic aqueous colloidal dispersion of a neoprene which has excellent polymer and colloidal stability. The physical properties of this latex are described in Table I.

Like other neoprenes, Type 400 does not require any "post-cure" to improve the strength of paper markedly. However, the polymer does crystallize over a period of time so that significantly higher strength is observed on aged papers than with those tested immediately after reaching equilibrium conditions.

Even though a "post-cure" is not needed to develop adequate strength, post heat treatment even further improves the strength of Type 400 treated paper. Thus, high temperature converting operations, such as used in sand-paper manufacture, actually benefit the paper. The data in Table II illustrate the effect of a post heat treatment of paper containing Type 400. In this example, Duracel 301-M, a 30-pound, creped, semibleached kraft, generally used in masking tape base manufacture, was impregnated with Type 400, containing 1% antioxidant only, to give a finished sheet containing 48% elastomer. The excess latex was removed by passing the wet sheet through squeeze rolls with a nip opening of 6 mils. The wet sheet was dried at 100°C. for 10 min. in a circulating hot air oven. Strip adhesion was determined using a method described by I. R. Dunlap (*5*), the assemblies being made after the papers were aged. Tensile strength and elongation values were obtained with an Instron machine pulling apart a 1-in. wide strip at a rate of 2 in. per min. The jaw spacing was four inches. Except for the 1 hr. strip adhesion data, all other samples were conditioned 24 hr. at 75°F. and 50% R.H. before testing.

These data illustrate not only the excellent initial properties of the Type 400 treated paper but also the heat stability of the polymer and its reduced tendency to degrade cellulosic materials.

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Compounding

An antioxidant is the only essential additive with Neoprene Latex Type 400. "Zalba" Special rubber antioxidant (a fortified hindered phenol) affords adequate heat resistance for most applications and exhibits good resistance to discoloration and staining. For applications requiring maximum heat resistance, especially those involving high temperature converting operations (such as sandpaper manufacture), 4,4′-thiobis (6-tertiary butyl-M-cresol)* is the suggested antioxidant. The optimum concentration is 0.5 to 1.5 parts dry antioxidant per 100 parts dry neoprene, depending on the end use. Consequently, each manufacturer must determine the required amount by subjecting the treated papers to simulated tests that accurately correlate with actual service exposure.

Table I. Physical Properties of Neoprene Latex Type 400

Solids content, %	50
Specific gravity at 25°C.	
Latex	1.15
Polymer	1.42
pH	12.8
pH decline at 90°C.	None after 10 days
Surface tension, dynes sq. cm.	37
Particle size range, mμ	0.1–0.2
Brookfield viscosity, cp.	12

Other additives that may be used to impart specific effects include surfactants, resins, waxes, metallic oxides, etc. Surfactants are generally employed to improve the mechanical stability of the latex compound, to increase the penetration rate of "hard-to-wet" saturating bases and to impart chemical stability to compounds designed to control migration in heavy boards (*6*).

Resins and waxes are commonly utilized to reduce compound costs in addition to imparting stiffness or softness as the case may be. For example, in gasket applications, a resin may be used to reduce compound materials cost, but then a wax like material may be required to compensate for the increased stiffness imparted by the resin. Most resinous materials reduce the strength of neoprene saturated paper.

Table II. Effect of Heat Treatment on Type 400 Paper

Strip adhesion, MD, oz./in.	
1 hour after bonding	48
1 day after bonding	56
Papers aged 1 day at 125°C.	68
Papers aged 4 days at 100°C.	73
Papers aged 12 days at 70°C.	75
Tensile strength, MD, lb./in. width	
Original	24
Papers aged 1 day at 125°C.	24
Papers aged 4 days at 100°C.	24
Papers aged 12 days at 70°C.	24
Elongation, MD, %	
Original	22
Papers aged 1 day at 125°C.	22
Papers aged 4 days at 100°C.	22
Papers aged 12 days at 70°C.	22
Color change	
None after any of the aging periods	

Type 400, however, is so inherently strong that moderate resin loadings are tolerable while still maintaining strength requirements.

Based on accelerated high temperature exposures and over one year's exposure at ambient temperatures, metallic oxides are not necessary with Type 400. If some application should develop where the use of a metallic oxide either as a curing agent or acid acceptor is indicated, 2.5 to 5.0 dry parts zinc oxide per 100 dry neoprene should be sufficient.

* Santowhite crystals.

Properties

Neoprene Latex Type 400 saturated papers can be used to make pressure sensitive tape backings, abrasive paper base, insoles and counters, gaskets and imitation leather base. In such products Type 400 contributes a high degree of: dry and wet strength; water, chemical, and oil resistance; dimensional stability; abrasion resistance; flexibility and folding endurance; and heat and flame resistance.

Table III compares the properties of boards treated with Neoprene Latex Type 400 and Neoprene Latex Type 842A. For the insole board the Type 400 latex saturating compound contained 1 p.h.r.* antioxidant and surfactants and ammonium salts to control migration (*6*). The type 842A latex saturating compound contained 5 p.h.r. zinc oxide, 2 p.h.r. antioxidant and surfactants and ammonium salts as in the Type 400 compound.

For the gasket comparison, the same type of compounds were used except that no materials for migration control were needed.

Insole Board. These boards were prepared by "on-the-machine" saturation using an alpha-cellulose base. All the properties desired from the neoprene treatment were markedly improved by using Type 400.

Table III. Typical Properties of Neoprene Saturated Papers

	Type 400	*Type 842A*
Insole Board		
Alpha-cellulose base		
Elastomer content, %	30	30
Abrasion resistance index	270	100
Rib strength, pli	90	60
Internal bond strength, p.s.i.	180	90
Tensile strength, MD, p.s.i.	2200	1700
Stiffness, MD, p.s.i.	2600	1500
Gasket		
Unbleached kraft base		
Elastomer content, %	45	45
Tensile strength, MD, p.s.i.	3500	3000
CMD, p.s.i.	2500	2000
Compressibility, at 1000 p.s.i., %	20	20
Recovery, %	50	40
Percent weight pick-up		
After 22 hr. at R.T. in Water	70	75
ASTM no. 3 Oil	38	45
ASTM reference fuel B	50	50

The 50% higher rib strength of the Type 400 treated material is indicative of the board's greater capacity to retain stitching during and after the shoe manufacturing operation. Holding the plies together more strongly for longer flex life is another important improvement imparted by Type 400. The 100% higher internal bond strength of Type 400 boards is a measurement of this improvement. The abrasion resistance of Type 400 boards is almost three times better. For example, samples tested on a Tabor Abrader under identical conditions showed only 25 mils gage loss for Type 400 boards versus 68 mils gage loss for those prepared from Type 842A.

Gasket. These papers were prepared by off-the-machine saturation using a typical untreated kraft base.

The higher uncured dry strength and better uncured recovery imparted by Type 400 are definite assets in gasket applications. The improved resistance to water and ASTM No. 3 oil are also major advantages when using Type 400.

* p.h.r. = dry parts per 100 dry parts neoprene.

BEATER ADDITION

Properties

The same heat resistance and strength improvements imparted by Neoprene Latex Type 400 as a saturant are realized when it is used as a beater additive. Table IV compares a Type 400 beater treated paper with a similarly treated Type 735 paper. Compared to Type 735, Type 400 has improved processibility with a high degree of elastomer retention over a wide range of addition.

Compounding and Processing

The procedure for adding Type 400 at the wet end is the same as that for adding any other neoprene latex. A brief outline follows.

1. Fresh water is used to prepare the furnish.
2. After all the beating to be done on the furnish is completed, the roll is raised and the pH is increased to a minimum of 8.0 with soda ash or dilute sodium hydroxide.
3. Antioxidant and, when necessary, zinc oxide are added. next. The amount and type of antioxidant was discussed under saturation. The beater treated product, like the saturated one, should be subjected to the necessary accelerated tests to establish the optimum amount of antioxidant to use.
4. The anionic stabilizer is the next material to be added. Anionic or nonionic type stabilizers could be used but anionics are preferred because of the foaming tendencies of the latter.

The amount of stabilizer will vary depending upon several factors—the amount of latex to be added, the type of furnish to be treated, and the quality of the fresh water. The function of the stabilizer is to retard the rate of coagulation upon addition of the alum coagulant. By slowing down the rate of coagulation, the coagulant can be more thoroughly distributed through the treated stock, before the latex becomes destabilized. This results in discrete deposition of the neoprene particles onto the fibers and the greatest possible bonding power from the neoprene can be realized. Instantaneous coagulation, on the other hand, produces large agglomerates resulting in nonuniform distribution of the neoprene among the fibers and poor sheet formation. However, the stabilizer does impair the effectiveness of the coagulant. Hence, excessive amounts could prevent some or all of the latex from being deposited, with the result that lower than anticipated strength development would be realized. This condition also would result in abnormally rapid felt filling and generally poor processibility. Thus, it is extremely important to establish the proper amount of stabilizer to use. This can readily be done by small-scale laboratory additions, reproducing as closely as possible the actual plant conditions.

Table IV. Comparison of Unbleached Kraft Treated with Type 400 Versus Type 735

	Type 400	*Type 735*
Elastomer content	25	25
Dry tensile strength, lb./in. width	40	28
Wet tensile strength, lb./in. width after 24 hr. immersion in water at room temperature	12	13
Internal bond, p.s.i.	190	165

Table V illustrates the effect of increasing amounts of stabilizer on the strength imparted by Type 400 latex. In this series, 20 parts dry neoprene were added to 100 parts dry bleached sulfite pulp. The stabilizer used was a sodium salt of polymerized alkyl naphthalene sulfonic acid.

5. Neoprene letex is then added.

The latex is usually gravity fed from the drum or other suitable hold tank through a spray pipe just before the beater roll. The consistency of the stock should be from 2 to 4% to assure adequate mixing without excessive mechanical agitation.

6. Coagulant is the last material added.

After all the latex is added, mixing is allowed to continue for a few more revolutions to allow complete distribution of the latex before the coagulant is introduced. Dilute solutions of alum are normally used as the coagulant. Sufficient alum is added to reduce the pH to 4.5 to 5.0. After the precipitation, the stock is handled in a normal fashion, except for two operations. Additional jordaning or beating should be avoided to minimize dislodging the latex particles from the fiber, and the tray water pH should be below 5.5. Dilute alum solution can be added to the recycling white water to accomplish this pH adjustment when necessary.

Table V. Effect of Stabilizer on Strength of Type 400 Beater Treated Sulfite Paper

	Parts stabilizer per 100 dry neoprene				
	0	*1*	*2*	*3*	*4*
Internal bond strength, p.s.i.	69	97	106	139	131
Dry tensile strength, lb./in. width	32	34	35	37	35
Wet tensile strength, lb./in. width	4	5	6	8	7
20% Lactic acid size, sec.	160	230	440	880	740

Type 400 latex, when stabilized and coagulated as described should present no unusual operating difficulties. The retention of Type 400 latex is considerably higher than normally obtained with other types of neoprene.

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On The Relationship Between Properties of Straw Pulp and Properties of Straw

F. M. MULLER

Experience had taught us that not only different species of straw (that is, rye, oats, wheat, and barley), but also different samples of the same species of straw (which may differ in the variety of the cereal, the type of soil on which it was grown and other agricultural factors), when treated in the same way, may yield pulps of rather different properties. It had also appeared that differences in the chemical composition by themselves did not give an adequate explanation of these differences in pulp properties.

Therefore, in the course of 1955, it was decided to start a thorough chemical, morphological, and anatomical investigation of eight kinds of straw, coupled with a digestion of these straws separately with caustic soda and with neutral sulphite, followed by bleaching these pulps, beating both bleached and unbleached pulps during different times and the determination of some properties of the handsheets formed from the beaten pulps.

Thus, an enormous mass of data was obtained, the elaboration of which took considerable time.

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MATERIAL AND METHODS

The following kinds of straw were employed:

(a) Rye (Petkuser) tetraploid* from peaty soil.
(b) Rye (Petkuser) diploid from sandy soil.
(c) Rye (Petkuser) diploid from peaty soil.
(d) Oats from sandy soil.
(e) Oats (Marne) from silty soil.
(f) Oats (Marne) from peaty soil.
(g) Summer wheat (Peko) from silty soil.
(h) Winter wheat (Heines VII) from silty soil.

Morphological, Anatomical and Chemical Investigation

Four to Six hundred stalks of each kind of straw were in the sampled field before harvesting by pulling them out of the soil. Moreover, after harvesting and threshing, one bale of each kind of straw was obtained, which was used for the digestions and for fiber classification.

In the laboratory, all stalks of one kind of straw were laid out and every fiftieth stalk was sampled for the anatomical investigation. The other stalks were stripped of the roots and divided into internodes, nodes, ears (panicles) and leaves + sheaths, the weight percentages of these parts being determined.

For the anatomical investigation, three cross sections were made of each stalk, namely, 1 cm. above the lowest node, in the middle and 1 cm. below the ear (panicle).

On these cross sections, various counts and measurements were made from which figures for a number of vascular bundles, percentage area of epidermis, sclerenchyma and parenchyma, etc., were derived.

For the fiber classification, 100 g. samples from the baled straw were macerated with the potassium chlorate nitric acid mixture according to Schulze's method,** followed by a fractionation with the Brecht-Holl apparatus over screens DIN 70, 25 and 16.

Chemical analysis was carried out separately on internodes, nodes, ears (panicles) and leaves + sheaths, according to the standardized methods in use at the Station and comprised ether solubles, hot water solubles, water insoluble ash and protein, lignin, pentosan, alpha-cellulose, carbon dioxide from uronic acids and acetyl. The total composition of the straw was calculated from the composition of the parts with the aid of the weight percentages mentioned above.

Digestions of Straw and Working Up of the Pulps Obtained

Digestions were carried out in duplicate in an electrically heated, rotating stainless steel laboratory autoclave of 15 l. capacity, according to the two recipes in the following table:

	Caustic	*Neutral sulphite*
Percentage chemical on straw	15% NaOH	13.6% Na_2SO_3 + 3.4% NaOH
Temperature, °C.	145	165
Duration at given temperature, hr.	3	3
Straw/liquor ratio	1:4	1:4
Amount of straw, g.	1500	1500

After digestion, the pH of the residual liquor and the total yield on ovendry straw were determined and the pulps screened over 0.3-mm. slits, with determination of the yields of the rejects and of the accepted pulp, also in percentage of ovendry straw. The pulps were analyzed for silica, insoluble ash, lignin, pentosan, and alpha-cellulose; in addition, the chlorine number† was determined.

Pulps were bleached with 3% gaseous chlorine, alkaline extraction and hypochlorite (equivalent to 3% Cl), the brightness after bleaching being determined with a Photovolt meter.

Both unbleached and bleached pulps were beaten in the Station's Jokro mill‡ for different times. The beaten pulps were made into handsheets of 67 g. per sq. m. the drainage time being determined; the handsheets were tested for breaking length, bursting and tearing strengths and folding number.

* Telioploid plants and animals have a all nucleus double the mass of the ordinary (diploid) plants and animals.

** *See Publicatie No. 7* by F. M. Muller, E. L. Ritman, and J. Molenaar, Netherlands Experiment Station for Straw Utilization, Groningen (1943).

† According to P. E. Trout, *et al.*, *Tappi* 36, 123 (1953).

Table I. Weight Percentages of Parts of Stalks

Kind of straw	*Internodes*	*Nodes*	*Ears*	*Leaves*
Rye tetraploid	63.1	4.9	10.5	21.5
Rye sandy soil	65.6	4.5	9.2	20.7
Rye peaty soil	61.5	4.6	9.6	24.3
Oats sandy soil	47.6	3.2	10.0	39.3
Oats silty soil	48.5	3.0	8.8	39.7
Oats peaty soil	47.7	3.3	9.6	39.4
Summer wheat	49.2	3.8	14.7	32.4
Winter wheat	43.2	3.8	19.9	33.0

RESULTS

The work yielded a large mass of data, not all of which can be presented here. The more important data are mentioned below.

Weight Percentages of Parts of Stalks (Table I)

Most of the weight is taken up by the internodes, followed by leaves + sheaths and ears (panicles), the nodes comprising but a small percentage. There is little difference among the three rye straws and the three oat straws, respectively. The internodes are much more prominent in rye than in oats and summer wheat; in winter wheat, they represent appreciably less than half of the total. Leaves + sheaths are more prominent in oats, less so in wheat and comprise only 20 to 25% in rye straw. The ears comprise but about 10% in rye and oat straws, but in summer and winter wheat straws 15 and 20%, respectively.

Fibre Fractionation of Macerates (Table II)

This fractionation shows comparatively little variation in the two middle fractions (>70 <25 21.2 to 28.6%, >25 <16 8.1 to 13.2%), a more pronounced one in the fine fraction (24.1 to 37.2%) and considerable variation in the coarse one (24.9 to 45.8%). Outstanding is the tetraploid rye with only 24.1% <70, but 45.8% >16. The other ryes, the oats and the winter wheat samples vary from 27.1 to 34.1% in the fines and from 27.9 to 36.2% in the coarse fraction. The summer wheat sample stands more or less apart with 37.2% <70 and 24.9% >16.§

Chemical Composition [Table III (a)-(f)]

When first comparing the averages for the various parts and for the total composition of the straw (Table III (f)), it appears that ether solubles (mostly epidermal wax), insoluble

‡ See Treatise No. 4 by Th. H. Asselman, W. v. d. Broek, J. G. Dijkhuis and F. M. Muller, Netherlands Experiment Station for Straw Utilization, Groningen (1956).

§ Fractionation was also applied to the unbleached soda and neutral sulphite pulps and yielded results that were on the whole similar to those of the macerates; however, the pulps from winter wheat yielded consistently more fines and less coarse fraction than would be expected from the general relationship between the figures for macerates and pulps.

Table II. Fibre Fractionation of Macerates, Percentage Weight

Kind of straw	*<DIN 70*	*>DIN 70 <DIN 25*	*>DIN 25 <DIN 16*	*>DIN 16*
Rye tetraploid	24.1	22.0	8.1	45.8
Rye sandy soil	32.9	21.2	9.8	36.2
Rye peaty soil	34.1	21.5	10.4	34.0
Oats sandy soil	30.8	26.7	13.0	29.7
Oats silty soil	27.1	27.6	13.0	32.4
Oats peaty soil	34.0	24.9	13.2	27.9
Summer wheat	37.2	28.6	9.4	24.9
Winter wheat	31.3	23.5	10.9	34.3

Table III(a). Chemical Composition of Internodes

Kind of straw	Ether solubles	Water solubles	Insoluble ash	Insoluble protein	Lignin[a]	Pentosan	Alpha-cellulose[b]	Carbon dioxide (uronic acids)	Acetyl	Summation
Rye tetraploid	0.9	10.8	0.4	0.9	19.0	24.2	40.6	1.0	1.9	99.7
Rye sandy soil	0.9	14.0	0.4	0.7	17.6	24.5	38.4	0.9	2.3	99.7
Rye peaty soil	1.0	9.9	0.4	0.9	18.4	25.5	40.4	1.0	2.5	100.0
Oats sandy soil	0.7	11.7	0.3	0.4	19.0	24.8	40.3	1.0	2.0	100.2
Oats silty soil	0.6	13.5	1.6	0.5	19.9	24.0	39.4	1.0	1.6	102.1
Oats peaty soil	0.7	13.2	0.4	0.5	18.9	24.6	39.4	1.0	1.3	100.0
Summer wheat	0.7	12.6	3.4	0.5	18.2	24.7	37.2	0.9	2.3	100.5
Winter wheat	0.8	9.9	2.6	0.9	20.2	24.8	39.9	1.1	2.4	102.6
Average	0.8	12.0	1.2	0.7	18.9	24.6	39.5	1.0	2.0	100.6

Table III (b). Chemical Composition of Nodes

Rye tetraploid	0.8	14.1	0.8	1.1	20.5	27.4	31.1	1.3	1.9	99.0
Rye sandy soil	0.7	22.6	0.2	1.4	17.3	24.5	25.9	1.2	1.9	95.7
Rye peaty soil	0.7	16.0	1.0	1.6	18.7	25.8	30.2	1.2	2.3	97.5
Oats sandy soil	0.8	14.0	1.1	0.8	17.6	27.9	31.9	1.2	2.9	98.2
Oats silty soil	0.5	17.7	0.8	0.6	18.4	26.0	30.9	1.1	2.3	98.3
Oats peaty soil	0.6	15.4	0.9	0.9	17.4	28.0	32.0	1.2	1.6	98.0
Summer wheat	1.7	16.2	1.8	1.1	18.6	25.0	29.6	1.3	2.0	97.3
Winter wheat	0.6	13.1	1.9	1.2	17.1	26.9	32.9	1.4	2.4	97.5
Average	0.8	16.1	1.1	1.1	18.2	26.4	30.6	1.2	2.2	97.7

[a] Ash-free.
[b] Ash-free and pentosan-free.

Table III (c). Chemical Composition of Ears (Panicles)

Kind of straw	Ether solubles	Water solubles	Insoluble ash	Insoluble protein	Lignin	Pentosan	Alpha-cellulose	Carbon dioxide (uronic acids)	Acetyl	Summation
Rye tetraploid	1.8	10.0	3.8	1.9	17.2	30.7	31.1	1.0	2.1	99.6
Rye sandy soil	1.4	11.9	3.0	1.8	16.3	32.2	30.0	1.1	2.4	100.1
Rye peaty soil	2.0	13.7	4.6	2.1	15.8	28.5	28.8	1.1	2.3	98.9
Oats sandy soil	2.6	13.9	1.2	1.3	14.7	32.6	30.1	1.0	2.2	99.6
Oats silty soil	2.5	14.7	9.2	1.1	14.7	28.4	28.9	0.9	1.5	101.9
Oats peaty soil	2.2	14.3	1.4	1.1	15.0	31.4	30.8	1.0	1.8	99.2
Summer wheat	1.0	9.5	13.6	1.3	14.1	27.0	29.1	0.8	2.1	98.5
Winter wheat	1.3	12.1	12.1	1.7	12.8	27.7	29.2	1.1	1.9	99.9
Average	1.9	12.5	6.1	1.5	15.1	29.8	29.8	1.0	2.0	99.7

Table III (d). Chemical Composition of Leaves + Sheaths

Rye tetraploid	2.6	11.0	3.1	2.2	16.6	26.1	35.1	1.0	1.5	99.2
Rye sandy soil	2.7	14.6	1.7	2.3	15.1	25.4	34.0	1.2	1.9	99.0
Rye peaty soil	2.8	10.1	2.7	2.4	15.2	27.4	34.1	1.1	2.0	97.8
Oats sandy soil	3.7	12.7	2.0	1.1	11.4	25.2	36.1	1.1	1.3	94.6
Oats silty soil	3.7	16.8	7.9	1.0	9.9	22.1	35.8	1.0	0.6	98.8
Oats peaty soil	3.7	13.8	3.6	1.3	11.2	23.6	36.3	1.2	1.0	95.7
Summer wheat	2.7	13.0	12.3	1.8	13.1	23.1	29.7	1.0	1.5	98.2
Winter wheat	2.5	16.4	12.7	3.6	12.4	22.1	26.9	1.0	1.5	99.1
Average	3.1	13.6	5.8	2.0	13.1	24.4	33.5	1.1	1.4	97.8

Table III (e). Total Chemical Composition of Straws

Kind of straw	Ether solubles	Water solubles	Insoluble ash	Insoluble protein	Lignin	Pentosan	Alpha-cellulose	Carbon dioxide (uronic acids)	Acetyl	Summation
Rye tetraploid	1.4	10.9	1.4	1.3	18.4	25.4	38.0	1.0	1.8	99.6
Rye sandy soil	1.3	14.3	0.9	1.2	17.0	25.4	36.2	1.0	2.2	99.5
Rye peaty soil	1.5	10.6	1.4	1.4	17.4	26.3	37.3	1.1	2.3	99.3
Oats sandy soil	2.1	12.4	1.1	0.8	15.6	25.9	37.4	1.1	1.8	98.2
Oats silty soil	2.0	15.3	4.7	0.8	15.4	23.7	36.8	1.0	1.2	100.9
Oats peaty soil	2.0	13.6	2.1	1.1	15.4	25.0	37.1	1.1	1.2	98.6
Summer wheat	1.4	12.4	7.7	1.1	16.0	24.6	33.4	0.9	2.0	99.5
Winter wheat	1.5	12.6	7.8	2.0	15.1	24.6	33.2	1.1	2.0	99.9
Average	1.7	12.8	3.4	1.2	16.3	25.1	36.2	1.0	1.8	99.4

Table III (f). Average Compositions

Internodes	0.8	12.0	1.2	0.7	18.9	24.6	39.5	1.0	2.0	100.6
Nodes	0.8	16.1	1.1	1.1	18.2	26.4	30.6	1.2	2.2	97.7
Ears (panicles)	1.9	12.5	6.1	1.5	15.1	29.8	29.8	1.0	2.0	99.7
Leaves + sheaths	3.1	13.6	5.8	2.0	13.1	24.4	33.5	1.1	1.4	97.8
Total	1.7	12.8	3.4	1.2	16.3	25.1	36.2	1.0	1.6	99.4

ash (mostly silica) and insoluble protein (nitrogen × 6.25) are concentrated in the ears and in the leaves + sheaths. The water solubles are somewhat higher in the nodes than in the other parts. On the other hand, the ears and leaves are lower in lignin than are the other parts, while the alpha-cellulose content of nodes, ears, and leaves is lower than that of the internodes. The pentosan content of the ears is appreciably higher than that of the other parts, which coincides with the lowest alpha-cellulose content; thus, the alpha-cellulose/pentosan ratio in the ears is only 1.0, whereas it amounts to 1.6 in the internodes. Carbon dioxide from uronic acids and acetyl show but little variation among the different parts of the straw.

When looking at the sums of the nine components included in the analyses, it is seen that on the whole the analyses of internodes and ears cover practically 100%, whereas in those of nodes and leaves there is a shortage of a little over 2%. One item that is not covered by the present series of determinations is hexosans belonging to the hemicellulose fraction. The sums in Table III (e) show that in the straw as a whole such hexosans occur in only insignificant amounts. However, it is possible that in the nodes and leaves they cannot be left out of consideration; moreover, the occurrence of small amounts of reserve carbohydrates like starch in the leaves seems feasible.

Judging from the chemical composition, the internodes are the most valuable part of the straw because of their high alpha-cellulose content, whereas the reverse holds for the ears; moreover, the latter have a high ash content, which is, at best, an inert component. The anatomy points in the same direction, because most of the longer fibers are to be found in the internodes and, to a lesser extent, in the sheaths and leaves. Ears and nodes contain very few long fibers.

Turning now to a comparison of the total chemical compositions of the eight kinds of straw [Table III (e)], it is observed that there are only minor differences among the kinds of rye, oat, and wheat straws by themselves. Among the rye straws, the only notable difference is the higher content of water solubles of the sample from sandy soil, which has indeed an exceptionally high value for a rye straw (mostly values below 10% are found). Among the oat straws, the sample from silty soil has a much higher insoluble ash content, which is a regular phenomenon in all cereals when grown in heavy soils compared with the same variety grown in light (sandy or peaty) soils. The compositions of the two wheat straw samples are quite similar all over.

A comparison of the compositions of rye, oat, and wheat straws with each other shows that oat straw differs from the others in a higher ether solubles content (probably a consequence of its high leaf content, see Table I). In general, oat straw has also a higher water solubles content, but, since this property may show considerable fluctuation among individual samples, it is not surprising that this is not borne out very clearly by the present analyses. The wheat straw samples stand out by their low alpha-cellulose and high ash contents, even when for the ash content it is borne in mind that both samples were grown on heavy soil (compare the oat straw from the same type of soil).

A few words may be said about the compositions of the various parts of the individual kinds of straw [Table III (a)–(d)]. When looking at the figures for alpha-cellulose, it is observed that in summer wheat most figures are consistently lower than those for the other kinds, but that in winter wheat this only holds for the leaves; however, the low percentage of internodes (the part with the highest alpha-cellulose content) in this kind of straw will also contribute to a low total alpha-cellulose content.

Table IV. Anatomical Characteristics of Straws (Averages of Bottom, Middle and Top)

Kind of straw	*Diameter of stalk, mm.*	*Thickness of wall, mm.*	*No. of vascular bundles*	*Percentage areas*		
				Epidermis	*Sclerenchyma*	*Parenchyma*
Rye tetraploid	3.50	0.56	43	6.8	27.4	65.8
Rye sandy soil	3.35	0.47	41	6.8	24.8	68.5
Rye peaty soil	3.33	0.46	46	8.6	25.8	65.7
Oats sandy soil	3.05	0.31	38	7.4	27.4	65.3
Oats silty soil	3.70	0.37	45	7.3	23.9	68.8
Oats peaty soil	3.91	0.39	49	6.3	24.0	69.7
Summer wheat	2.98	0.44	48	6.7	25.5	67.8
Winter wheat	2.99	0.56	49	5.0	25.6	69.5

Anatomical Characteristics (Table IV)

Table IV contains data on the diameter of the stalks, the thickness of the wall of the internodes, the number of vascular bundles in the stalks and the percentage areas of the three principal tissues epidermis, sclerenchyma (comprising most of the true fibers) and parenchyma. All figures are the averages of values for bottom, middle, and top internodes (see under morphology).

Table V (a). Data on Digesting and Bleaching of Soda Pulps (Bleach Yield on Pulp, Other Yields on Straw)

Kind of straw	*Final pH*	*Total*	*Yields*		*Bleach*	*Chlorine no.*	*Chlorine consumption*	*Brightness*
			Accept	*Reject*				
Rye tetraploid	12.0	55.8	50.7	3.7	93.2	2.9	5.4	78[5]
Rye sandy soil	12.4	54.0	48.6	3.5	95.7	3.1	5.3	80
Rye peaty soil	12.3	55.8	51.1	3.7	92.3	3.0	5.2	78
Oats sandy soil	12.2	52.5	48.9	1.7	92.3	3.0	5.2	79
Oats silty soil	12.2	51.0	48.4	1.6	89.7	2.9	5.2	79
Oats peaty soil	12.1	50.9	47.8	1.4	91.9	2.7	4.9	78[5]
Summer wheat	11.7	55.8	50.3	3.9	92.3	3.8	5.5	78[5]
Winter wheat	11.7	55.5	49.0	3.4	93.2	3.4	5.4	78

Table V (b). Data on Digesting and Bleaching of Neutral Sulphite Pulps

Rye tetraploid	9.8	61.3	57.6	2.0	89.3	2.7	5.0	80
Rye sandy soil	10.1	60.0	56.2	1.9	90.6	3.0	4.8	79[5]
Rye peaty soil	10.0	59.5	57.6	1.3	94.9	2.7	4.6	80
Oats sandy soil	10.2	57.7	54.9	0.7	91.1	2.6	4.7	78[5]
Oats silty soil	10.2	58.4	54.6	0.5	94.9	2.7	4.6	80
Oats peaty soil	10.1	58.6	54.6	0.6	91.9	2.5	4.9	79
Summer wheat	10.0	61.2	57.4	1.5	94.1	2.4	4.3	80
Winter wheat	10.0	60.1	54.8	2.2	94.0	2.6	4.7	80

Table VI (a). Chemical Composition of Unbleached Soda Pulps

Kind of straw	*Insoluble ash*	*Lignin*	*Pentosan*	*Alpha-cellulose*	*Summation*	*Alpha-cellulose / pentosan*
Rye tetraploid	1.8	3.3	28.3	64.9	98.3	2.3
Rye sandy soil	2.1	3.4	26.6	65.2	97.3	2.5
Rye peaty soil	2.1	3.8	26.7	65.1	97.7	2.4
Oats sandy soil	2.4	3.2	25.1	65.6	96.3	2.6
Oats silty soil	2.6	3.7	24.0	68.7	99.0	2.9
Oats peaty soil	2.9	2.9	24.2	66.7	96.7	2.7
Summer wheat	2.4	4.2	30.9	60.8	98.3	2.0
Winter wheat	3.4	4.0	31.5	59.9	98.8	1.9

Table VI (b). Chemical Composition of Unbleached Neutral Sulphite Pulps

Rye tetraploid	1.7	3.3	30.4	61.3	96.7	2.0
Rye sandy soil	2.4	3.4	28.5	64.8	99.1	2.3
Rye peaty soil	1.9	3.7	30.9	64.8	101.3	2.1
Oats sandy soil	3.6	3.4	27.7	65.1	99.8	2.4
Oats silty soil	5.8	3.8	26.7	63.6	99.9	2.4
Oats peaty soil	3.1	3.5	27.8	65.1	99.5	2.3
Summer wheat	11.3	3.6	28.8	58.1	101.8	2.0
Winter wheat	10.5	3.7	27.7	55.3	97.2	2.0

The average diameter of the stalk differs a great deal among the oats samples, but only little among the rye or wheat samples; stalk diameter is lower in the wheat samples than in the other ones. It should be noted that the thickness of the internode wall is less in the oat straw than in the others; however, differences among the rye and wheat straws are rather big. Neither the number of vascular bundles, nor the area percentages of the three tissues show any remarkable trend among the eight kinds of straw.

Digestion of the Straws and Bleaching of the Pulps [Tables V(a) and (b)]

Soda Digestion—Final pH of the cooking liquor does not vary much; the wheat straws show a tendency toward a somewhat lower value. Comparison with Table III (e) shows that this is not caused by a higher acetyl content of wheat straw. Total yield is distinctly lower in the digestion of oat straw, which is in line with general experience in industry. The current explanation for this lower yield is the usually higher water solubles content of oat straw; however, the data in Table III (e) show that among the present samples no close correlation exists between total yield and water solubles content. The rejects are distinctly lower in the oat straw pulps; therefore, differences among the yields of accepted pulp are much smaller* and do not show any distinct trend. Chlorine numbers, bleach yields, chlorine consumptions and brightnesses do not call for comment.

* During the screening operation, some fines are lost; however, this loss amounts to 1.0 to 1.9% only, with the exception of the winter wheat pulps, where 3.1% is lost.

Neutral Sulphite Digestion—The final pH is practically the same throughout. The general level of the total yield is somewhat higher than in the soda cooks and shows the same trend of lower values for the oat straw pulps, albeit to a lesser extent. Again the rejects are distinctly lower in the oat straw pulps, but the values for the accepted pulps are somewhat erratic, owing to rather divergent screening losses (0.6 to 3.4%). Here too the figures for chlorine numbers, etc., do not show any distinct trend.

Chemical Composition of Unbleached Pulps [Tables VI (a)–(d)]

Soda Pulps—In these pulps, the insoluble ash shows little variation, although there is a tendency to somewhat lower values in the rye straw pulps. The same holds for the lignin figures. Pentosan content is lowest in the oat straw and highest in the wheat straw pulps, while the latter contain distinctly less alpha-cellulose than the others; this is in line with the lower alpha-cellulose content of the wheat straw samples. Thus, the alpha-cellulose/pentosan ratio is lowest in the wheat straw pulps (average 2.0), while, in the oat straw pulps (average 2.7), it is somewhat higher than in the rye straw pulps (average 2.4.). The analysis of the four components covers 96.3 to 99.0% of the total solids. The remainder will be composed of a little ether solubles and water solubles, nitrogenous matter, etc.

In Table VI (c), a calculation is given of the yields of alpha-cellulose and pentosan in the soda pulps. With the aid of the figures for total yield from Table V (a), the alpha-cellulose and pentosan contents of the pulps are converted to percent-

Table VI (c). Calculation of Yields of Alpha-Cellulose and Pentosan in Soda Pulps

		Percentage of oven-dry straw					
		Alpha-cellulose			*Pentosan*		
Kind of straw	*Total yield*	*Straw*	*Pulp*	*Difference*	*Straw*	*Pulp*	*Difference*
Rye tetraploid	55.8	38.0	36.2	−1.8	25.4	15.8	− 9.6
Rye sandy soil	54.0	36.2	35.2	−1.0	25.4	14.4	−11.0
Rye peaty soil	55.8	37.3	36.3	−1.0	26.3	14.9	−11.4
Oats sandy soil	52.5	37.4	34.5	−2.9	25.9	13.2	−12.7
Oats silty soil	51.0	36.8	35.0	−1.8	23.7	12.2	−11.5
Oats peaty soil	50.9	37.1	34.0	−3.1	25.0	12.3	−12.7
Summer wheat	55.8	33.4	34.0	+0.6	24.6	17.2	− 7.4
Winter wheat	55.5	33.2	33.4	+0.2	24.6	17.5	− 7.1

Table VI (d). Calculation of Yields of Alpha-Cellulose and Pentosan in Neutral Sulphite Pulps

Rye tetraploid	61.3	38.0	37.6	−0.4	25.4	18.6	− 6.8
Rye sandy soil	60.0	36.2	38.8	+2.6	25.4	17.1	− 8.3
Rye peaty soil	59.5	37.3	38.6	+1.3	26.3	18.4	− 7.9
Oats sandy soil	57.7	37.4	37.6	−0.2	25.9	16.0	− 9.9
Oats silty soil	58.4	36.8	37.1	+0.3	23.7	15.6	− 8.1
Oats peaty soil	58.6	37.1	38.1	+1.0	25.0	16.3	− 8.7
Summer wheat	61.2	33.4	35.6	+2.2	24.6	17.6	− 7.0
Winter wheat	60.1	33.2	33.3	+0.1	24.6	16.7	− 7.9

ages of original straw and the loss (or gain) of these components is found by subtracting these percentages from the corresponding ones of the straw [see Table III (e)]. It is seen that, in the soda digestion of the rye and oat straws, there is a small loss of alpha-cellulose, which, on the whole, is higher in that of the oat straws; in the wheat straws, a minute gain is found, which is, however, within the limits of error of the determinations involved. The losses in pentosan are correspondingly highest in the oat straw pulps, somewhat less in the rye straw pulps, markedly less in the wheat straw pentosan contents show little variation, although there is a certain tendency to somewhat higher values in the rye straw and somewhat lower values in the oat straw pulps. The alpha-cellulose content of the wheat straw pulps is again distinctly lower than that of the others. The alpha-cellulose/pentosan ratio shows the same tendency as among the soda pulps, but to a lesser extent. The sum of the four components is quite near 100%.

The calculation of the losses in alpha-cellulose and pentosan [Table VI (d)] show in general much lower figures than for

Table VII (a). Mechanical Properties of Unbleached Soda Pulps After 10 Min. Beating Time

Kind of straw	*MDT sec.*[a]	*Breaking length, km.*	*Bursting strength, kg./cm.*	*Tearing strength, g.*	*Log double folds*	*Evaluation number*[b] *MDT incl.*	*MDT excl.*
Rye tetraploid	7.9	9.3	4.7	37	3.2	14.7	16.3
Rye sandy soil	10.0	8.7	4.1	36	2.8	12.9	14.9
Rye peaty soil	13.6	9.3	4.6	42	3.1	13.9	16.6
Oats sandy soil	13.6	8.0	4.1	36	2.9	11.9	14.6
Oats silty soil	10.6	8.2	4.2	42	2.8	13.2	15.3
Oats peaty soil	15.8	8.3	4.4	37	3.1	12.2	15.4
Summer wheat	10.8	8.2	3.8	34	2.7	11.8	14.0
Winter wheat	12.6	8.3	3.9	26	2.8	11.0	13.5

Table VII (b). Mechanical Properties of Unbleached Soda Pulps After 15 Min. Beating Time

Rye tetraploid	9.6	9.9	4.9	36	3.2	14.8	16.7
Rye sandy soil	13.6	9.4	4.4	35	2.9	12.8	16.5
Rye peaty soil	17.9	10.0	4.9	41	3.2	13.6	17.2
Oats sandy soil	19.4	8.5	4.4	35	3.1	11.4	15.3
Oats silty soil	13.9	8.9	4.5	37	3.0	12.9	15.7
Oats peaty soil	21.4	9.6	4.9	36	3.3	12.3	16.6
Summer wheat	14.4	8.9	4.1	32	2.9	11.8	14.7
Winter wheat	16.7	8.4	3.9	26	3.0	10.4	13.7

[a] MDT = mean drainage time on sheet machine.
[b] Calculation of evaluation number:

$$\frac{\text{Breaking length}}{2} + \text{Burst} + \frac{\text{Tear}}{10} + \log \text{folds} \left(- \frac{\text{MDT}}{5}\right)$$

pulps. These figures show that the lower yields of the oat straw pulps are probably caused to a large extent by a stronger attack on the cell-wall carbohydrates. This attack is also higher in the case of the rye straw pulps in comparison with the wheat straw pulps, but apparently its effect on the yield in the former is matched by the attack of the caustic liquor on the insoluble ash (silica) in the latter. The stronger action of the cooking recipe employed on the oat straw is also expressed by the lower figures for rejects in Table V (a).

Neutral Sulphite Pulps.—The less alkaline reaction of the liquor entails a much weaker action on the insoluble ash than in the case of the soda cooks, so that the ash contents of the pulps more or less follow those of the straws [see Table III (e)]. The lignin contents are practically the same. The the soda pulps. In some cases, there is even an apparent gain in alpha-cellulose. These figures may indicate a tendency toward an intimate association of some pentosan with the true cellulose during the cook, so that, even during the boiling with 12% HCl in the pentosan determination on the alpha-cellulose, this associated pentosan is not converted to furfural. Loss in pentosan is still somewhat higher in the oat straw pulps than in the others, which explains to a certain extent the differences in yield that are, however, smaller than in the soda cooks. This lower yield, together with the lower percentage of rejects in Table V (b), is again an expression of the stronger attack on the oat straw than on the other straws of the cooking liquor employed.

Table VII (c). Mechanical Properties of Bleached Soda Pulps After 10 Min. Beating Time

Kind of straw	*MDT, sec.*	*Breaking length, km.*	*Bursting strength, kg./cm.*[2]	*Tearing strength, g.*	*Log double folds*	*Evaluation number MDT incl.*	*MDT excl.*
Rye tetraploid	7.2	8.3	4.1	34	2.9	13.4	14.8
Rye sandy soil	10.8	8.5	3.4	36	3.0	12.1	14.3
Rye peaty soil	14.5	8.6	4.0	33	3.1	11.8	14.7
Oats sandy soil	12.6	8.0	3.7	34	2.7	11.3	13.8
Oats silty soil	20.2	7.5	4.1	32	3.1	10.3	14.3
Oats peaty soil	24.0	7.0	4.1	24	2.8	8.0	12.8
Summer wheat	12.3	8.7	4.1	31	3.1	12.2	14.7
Winter wheat	15.5	7.9	4.0	26	3.2	10.7	13.8

Table VII (d). Mechanical Properties of Bleached Soda Pulps After 15 Min. Beating Time

Rye tetraploid	8.7	8.6	4.3	31	3.0	13.0	14.7
Rye sandy soil	14.6	9.2	3.8	34	3.2	12.1	15.0
Rye peaty soil	25.8	9.1	4.2	32	3.2	10.0	15.2
Oats sandy soil	17.2	8.3	3.9	31	2.9	10.7	14.1
Oats silty soil	27.4	8.1	4.3	29	3.3	9.1	14.6
Oats peaty soil	31.4	6.7	4.0	21	3.0	6.2	12.5
Summer wheat	15.0	9.1	4.2	29	3.3	12.0	15.0
Winter wheat	20.8	8.6	3.7	26	3.2	9.6	13.8

Table VII (e). Mechanical Properties of Unbleached Neutral Sulphite Pulps After 10 Min. Beating Time

Kind of straw	MDT sec.	Breaking length, km.	Bursting strength kg./cm.²	Tearing strength, g.	Log double folds	Evaluation number MDT incl.	Evaluation number MDT excl.
Rye tetraploid	9.4	9.5	4.5	35	3.1	14.0	15.9
Rye sandy soil	11.2	9.1	3.3	33	2.9	11.9	14.1
Rye peaty soil	13.8	9.3	4.7	32	2.9	12.7	15.4
Oats sand soil	13.0	8.5	4.0	28	2.7	11.2	13.8
Oats silty soil	15.0	8.0	3.8	31	2.8	10.7	13.7
Oats peaty soil	24.8	8.2	4.1	26	3.0	8.8	13.8
Summer wheat	15.8	6.2	3.1	28	2.9	8.7	11.9
Winter wheat	12.4	5.3	3.2	23	3.1	8.8	11.3

Table VII (f). Mechanical Properties of Unbleached Neutral Sulphite Pulps After 15 Min. Beating Time

Rye tetraploid	11.4	9.7	4.7	32	3.1	13.6	15.9
Rye sandy soil	16.6	9.2	3.4	32	3.0	10.9	14.2
Rye peaty soil	17.7	9.5	4.8	34	3.1	12.6	16.1
Oats sandy soil	18.0	8.9	4.1	29	2.9	10.8	14.4
Oats silty soil	17.0	8.4	3.7	30	2.8	10.3	13.7
Oats peaty soil	31.0	6.4	3.4	27	3.0	6.1	12.3
Summer wheat	22.5	6.0	3.2	27	2.6	7.0	11.5
Winter wheat	18.0	5.2	3.2	22	2.6	7.0	10.6

***Mechanical Properties of Pulps* [*Tables VII (a)–(h)*]**

Of the various beating times applied, those of 10 min. and 15 min. were selected for representation in the tables, as the optimum strength is obtained around these beating times. In order to represent the properties in one figure, an evaluation number* was calculated according to the formula mentioned underneath Table VII (b). This formula was chosen with the intention of equalizing the influence of the five properties as far as possible. For reasons to be explained below, an evaluation number without the mean drainage time (MDT) was also calculated.

Tables VII (a)–(h) contain the results of unbleached and bleached soda and unbleached and bleached neutral sulphite pulps each for the two beating times separately. A survey of this wealth of data is more easily obtained from the average figures for the various groups of pulps that are collected in Table VIII.

1. Comparison of Soda and Neutral Sulphite Pulps. The two cooks yielded pulps of similar drainage time, but the strength of the neutral sulphite pulps is somewhat lower than that of the soda pulps. Thus, there is a distinct difference in both evaluation numbers in favor of the soda pulps.

2. Comparison of Unbleached and Bleached Pulps. Again there is but a small difference in drainage time. The strength properties are decreased a little by bleaching, with the exception, perhaps, of the folding number. Thus, the evaluation numbers are a little lower for the bleached pulps.

* See Th. H. Asselmaa, F. M. Muller, and P. M. Smolders, Treatise No. 2, Netherlands Experiment Station for the Utilization of Straw, Groningen (1852).

3. Comparison of 10 Min. and 15 Min. Beating Times. It stands to reason that the drainage time increases with beating time. However, there is no significant difference in strength properties between the two beating times. Therefore, the evaluation number including drainage time is a little lower for the pulps beaten for 15 min., whereas the numbers excluding drainage time are practically the same.

4. Comparison of Pulps from the Eight Kinds of Straw. With regard to the drainage time, the outstanding features are the comparatively low value for the pulps from tetraploid rye straw and the comparatively high value for those from oat straw from peaty soil. The pulps from rye straw from peaty soil show a distinctly higher value than those from rye straw from sandy soil. The differences between the pulps from the other two oat straws and from the two wheat straws are of minor importance.

Breaking length is highest in the rye straw and lowest in the wheat straw pulps. There is a little variation among the rye straw pulps, while, among the oat straw pulps, those from straw from peaty soil show a somewhat lower value; the same holds for the pulps from winter wheat straw among the wheat straw pulps.

Bursting strength is on the whole of the same order of magnitude in rye straw and oat straw pulps; however, the pulps from rye straw from sandy oil show a distinctly lower average than the other two rye straw pulps. The wheat straw pulps yielded lower figures than the other ones.

Tearing strength shows little difference among the rye straw pulps and the oat straw pulps from sandy and silty soils; lower values were found for the oat straw pulps from peaty

Table VII (g). Mechanical Properties of Bleached Neutral Sulphite Pulps After 10 Min. Beating Time

Kind of straw	MDT sec.	Breaking length, km.	Bursting strength, kg./cm.²	Tearing strength, g.	Log double folds	Evaluation number MDT incl.	Evaluation number MDT excl.
Rye tetraploid	8.4	9.0	4.1	32	2.8	12.9	14.6
Rye sandy soil	12.7	8.5	3.3	27	3.0	10.8	13.3
Rye peaty soil	13.0	8.0	3.6	28	2.7	10.5	13.1
Oats sandy soil	15.0	7.3	3.7	29	2.7	10.0	13.0
Oats silty soil	14.8	8.5	3.8	29	2.9	10.9	13.9
Oats peaty soil	21.0	8.3	3.6	25	2.8	8.9	13.1
Summer wheat	13.0	5.9	3.0	24	2.4	8.2	10.8
Winter wheat	12.5	5.3	2.8	22	2.3	7.5	10.0

Table VII (h). Mechanical Properties of Bleached Neutral Sulphite Pulps After 15 Min. Beating Time

Rye tetraploid	9.2	8.5	3.9	32	2.8	12.4	14.3
Rye sandy soil	16.8	8.6	3.6	27	3.1	10.3	13.7
Rye peaty soil	22.1	7.9	3.4	28	2.9	8.7	13.1
Oats sandy soil	18.5	7.4	4.0	27	3.0	9.7	13.4
Oats silty soil	17.7	8.3	3.7	27	2.7	9.8	13.3
Oats peaty soil	28.0	6.9	3.0	25	2.8	6.2	11.8
Summer wheat	19.1	5.3	3.1	24	2.1	8.5	12.3
Winter wheat	12.5	5.1	2.2	20	2.7	6.8	9.3

Table VIII. Average Values of the Mechanical Properties of the Pulps

Kind of straw	MDT, sec.	Breaking length, km.	Bursting strength, kg./cm.²	Tearing strength, g.	Log double folds	Evaluation MDT incl.	Evaluation MDT excl.
Rye tetraploid	9.0	9.1	4.4	34	3.0	13.6	15.4
Rye sandy soil	13.3	8.9	3.7	33	3.0	11.8	14.5
Rye peaty soil	17.3	9.0	4.3	34	3.0	11.7	15.2
Oats sandy soil	15.9	8.1	4.0	31	2.9	10.9	14.1
Oats silty soil	17.1	8.2	4.0	32	2.9	10.9	14.3
Oats peaty soil	24.7	7.7	3.9	28	3.0	8.6	13.5
Summer wheat	15.4	7.3	3.6	29	2.8	10.0	13.1
Winter wheat	15.1	6.8	3.4	24	3.0	9.0	12.0
Soda pulps	15.6	8.6	4.2	33	3.0	11.7	14.8
Neutral sulphite pulps	16.3	7.7	3.6	28	2.8	9.9	13.2
Unbleached	15.3	8.4	4.1	33	3.0	11.5	14.6
Bleached	16.6	7.9	3.7	28	2.9	10.2	13.5
10 min. beating time	13.7	8.1	3.9	31	2.9	11.2	13.9
15 min. beating time	18.3	8.2	4.0	30	3.0	10.4	14.1

soil and for the wheat straw pulps, especially for those from winter wheat straw.

The figures for the logarithm of the folding number show little variation. The evaluation numbers present an interesting picture. With drainage time included, there is again a comparatively high value for the pulps from the tetraploid rye straw and a comparatively low one for those from oat straw from peaty soil; the latter pulps even show a lower value than the wheat straw pulps and thus fall out of line with the other oat straw pulps. A comparison with the corresponding numbers excluding drainage time shows that these extreme values are due to the extreme values of the drainage times of the respective pulps. However, since drainage time is certainly an important property from a practical point of view, there is a sound reason for accepting the evaluation number including drainage time as a preliminary means of classification of the eight kinds of straw. This classification therefore becomes—

Tetraploid rye > diploid rye† > oats from sandy and silty soils > summer wheat >winter wheat > oats from peaty soils

The numbers of pulps from rye straw from sandy and peaty soils are practically equal, the influence of the lower drainage time compensating that of the lower strength figures of the former pulps.

Looking more closely at the evaluation numbers excluding drainage time, it appears that the pulps from rye straw from sandy soil lag a little behind the other rye straw pulps and are more or less on the same level as the oat straw pulps from sandy and silty soils. The oat straw pulps from peaty soils lie between the other oat straw and the summer wheat straw pulps, while the latter are distinctly above the winter wheat straw pulps. This means—

† Comprising the rye straw samples from sandy and peaty soils.

Tetraploid rye $\geqslant$ rye from peaty soil > rye from sandy soil $\geqslant$ oats from silty soil $\geqslant$ oats from sandy soil > oats from peaty soil > summer wheat $\geqslant$ winter wheat

DISCUSSION OF RESULTS

As stated in the introduction, the aim of the investigation has been to try to find a correlation between properties of straws and of the pulps obtained from them. The first requirement for the success of such an investigation is the selection of kinds of straw that show distinct differences in a number of properties; the second requirement is the selection of pulping processes that will yield pulps showing distinctly different properties. The data presented under Results show that these two requirements are satisfied.

A second question that should be looked into is whether the procedure adopted under 4 is justified for surveying of the mechanical properties of the pulps prepared from the eight kinds of straw by means of the average values for soda and neutral sulphite, bleached and unbleached pulps, beaten for 10 min. and 15 min. In order to answer this question, partial averages of the two evaluation numbers were calculated for (a) the four soda pulps against the four neutral sulphite pulps, (b) the four unbleached pulps against the four bleached pulps and (c) the four pulps beaten for 10 min. against the four pulps beaten for 15 min. The figures so obtained are collected in Tables IX (a) and (b). When comparing these partial averages with the corresponding totals in Table VIII, it appears that, although sometimes a slight reversal of the order of the values for the various pulps occurs, there is satisfactory agreement on the whole.

With regard to yields and chemical composition of the pulps, the principal feature is the lower yields and higher

Table IX (a). Partial Average Values of Evaluating Numbers Including Mean Drainage Time

Kind of straw	Soda pulps	Neutral sulphite pulps	Unbleached pulps	Bleached pulp	10-Min. beating	15-Min. beating
Rye tetraploid	14.0	13.2	14.3	12.8	13.8	13.5
Rye sandy soil	12.5	11.0	12.1	11.3	11.9	11.5
Rye peaty soil	12.3	11.1	13.2	10.3	12.2	11.2
Oats sandy soil	11.3	10.4	11.3	10.4	11.1	10.7
Oats silty soil	11.4	10.4	11.8	10.0	11.3	10.5
Oats peaty soil	9.7	7.5	9.9	7.3	9.5	7.7
Summer wheat	12.0	8.1	9.8	10.2	10.2	9.8
Winter wheat	10.4	7.5	9.3	8.7	9.5	8.5

Tabld IX (b). Partial Average Values of Evaluation Numbers Excluding Mean Drainage Time

Rye tetraploid	15.6	15.2	16.2	14.6	15.4	15.4
Rye sandy soil	15.2	13.8	14.9	14.1	14.2	14.9
Rye peaty soil	15.9	14.4	16.3	14.0	15.0	15.4
Oats sandy soil	14.5	13.7	14.5	13.6	13.8	14.3
Oats silty soil	15.0	13.7	14.6	14.0	14.3	14.3
Oats peaty soil	14.3	12.8	14.5	12.6	13.8	13.3
Summer wheat	14.6	11.6	13.0	13.2	12.9	13.4
Winter wheat	13.7	10.3	12.3	11.7	12.2	11.9

Table X. Comparison of Straw Properties with Total Yields and Rejects of Pulps

Kind of straw	Chemical composition[a]	Leaves, %	Wall thickness, mm.	Soda pulp		Neutral sulphite pulp	
				Total yield, %	Rejects, %	Total yield, %	Rejects, %
Rye tetraploid	12.1	21.5	0.56	55.8	3.7	61.3	2.0
Rye sandy soil	7.1	20.7	0.47	54.0	3.5	60.0	1.9
Rye peaty soil	12.0	24.3	0.46	55.8	3.7	59.5	1.3
Oats sandy soil	8.2	39.3	0.31	52.5	1.7	57.7	0.7
Oats silty soil	8.0	39.7	0.37	51.0	1.6	58.4	0.5
Oats peaty soil	7.1	39.4	0.39	50.9	1.4	58.6	0.6
Summer wheat	14.7	32.4	0.44	55.8	3.9	61.2	1.5
Winter wheat	13.8	33.0	0.56	55.5	3.4	60.1	2.2

[a] Ether solubles + insoluble ash + lignin + acetyl − water-solubles.

alpha-cellulose/pentosan ratios of the oat straw pulps. As already mentioned, this feature points toward a higher susceptibility of the oat straws to the cooking conditions employed.

When looking for straw properties that might influence this susceptibility, the following should be considered.

Chemical Properties. Ether solubles (waxes, etc.), insoluble ash (silica), lignin and acetyl will all bind some cooking chemical and thus exert a negative influence upon the susceptibility; on the other hand, the water solubles will go into solution at the beginning of the digestion and so will depress the yield, perhaps even enhance the susceptibility.

Morphological and anatomical properties. Of the various parts of the stalks, the leaves and sheaths will be more accessible to the cooking chemicals than the internodes and ears, while the nodes will be least accessible of all. Moreover, accessibility of the internodes will be greater the thinner their wall.

In Table X, the above-mentioned properties of the eight kinds of straw are listed, together with the total yields and rejects of the soda and neutral sulphite pulps. A qualitative parallelism of the two sets of data undoubtedly exists, but it is hard to tell what the quantitative influence of the three straw properties will be; moreover, the possibility exists that other factors not considered in the present investigation also come into play.

A similar line of thought may be followed for the mechanical properties of the pulps.

Among the *chemical properties* of the straws, the sum of alpha-cellulose and pentosan may be rated as a positive factor and the insoluble ash as a negative one; judging from the chemical composition of the pulps, the other chemical properties may be considered irrelevant in this respect.

Among the *morphological properties,* the following may be considered of importance (the anatomical properties having probably little influence)—positive factors are the percentages of internodes and the fraction > DIN 16, whereas the percentage of ears and the fraction > DIN 70 are negative factors. The other properties are considered to have little influence.

In Table XI, these straw properties are compared with the two average evaluation numbers of the pulps from Table VIII. The quantitative appraisal of the various positive and negative factors is again a difficult matter; however, as a first approximation, the sum of the positive factors minus the sum of the negative factors (that is, percentage of alpha-cellulose and pentosan plus percentage of internodes plus percentage of fraction > 16 minus percentage of insoluble ash minus percentage of ears minus percentage of fraction <70) is given below, in comparison with the two evaluation numbers.

	Rye tetr.	Rye sand	Rye peat	Oats sand
Positive plus negative factors	136	120	114	99
I. Evaluation no. (MDT incl.)	13.6	11.8	11.7	10.9
II. Evaluation no. (MDT excl.)	15.4	14.5	15.2	14.1
	Oats silt	Oats peat	Summer wheat	Winter wheat
Positive plus negative factors	101	92	73	76
I. Evaluation no. (MDT incl.)	10.9	8.6	10.9	9.0
II. Evaluation no. (MDT excl.)	14.3	13.5	13.1	12.0

When comparing the algebraic sum of positive and negative factors with the evaluation numbers including mean drainage time (I), there appears to be a fair agreement for the three rye straws and the oat straws from sandy and silty soil; for oat straw from peaty soil, the agreement is lacking and for the two wheat straws it is distinctly less. When looking at the algebraic sum in comparison with the evaluation numbers excluding mean drainage time (II), it is seen that the oat straw from peaty soil falls more or less into line, but that the reversal of the two wheat straws still exists; moreover, the agreement among the rye straws is less satisfactory than it is in the first case.

As already pointed out (see Table VIII), the high evaluation number I for tetraploid rye straw pulps is due to their low mean drainage time, therefore a relationship with the high percentage of the fraction > DIN 16 and the low percentage of the fraction < DIN 70 suggests itself. However, the high drainage time of oat straw pulps from peaty soil (which is responsible for their low evaluation number I) is not accompanied by the lowest figure for the fraction >16 and the highest value for fraction <70, which are found in the summer wheat straw. This straw yielded pulps of a much lower drainage time, which is practically the same as that of winter wheat straw pulps and of pulps from oat straw from sandy soil. Moreover, the higher drainage time of the rye straw pulp from peaty soil compared with that from sandy soil finds no counterpart in the figures for the two fractions of these straws. Thus, there must be still another factor influencing drainage time that is not included in the present investigation.

As already pointed out, the agreement between the algebraic sum and the evaluation number II, although better than in the case of evaluation number I, is by no means per-

Table XI. Comparison of Straw Properties with Evaluation Numbers of Pulps

Kind of straw	Alpha-cellulose + pentosan	Insoluble ash	Internodes	Ears	Fraction		Evaluation No.	
					>16	<70	MDT incl.	MDT excl.
Rye tetraploid	63.4	1.4	63.1	10.5	45.8	24.1	13.6	15.4
Rye sandy soil	61.6	0.9	65.6	9.2	36.2	32.9	11.8	14.5
Rye peaty soil	63.6	1.4	61.5	9.6	34.0	34.1	11.7	15.2
Oats sandy soil	63.3	1.1	47.6	10.0	29.7	30.8	10.9	14.1
Oats silty soil	60.5	4.7	48.5	8.8	32.4	27.1	10.9	14.3
Oats peaty soil	62.1	2.1	47.7	9.6	27.9	34.0	8.6	13.5
Summer wheat	58.0	7.7	49.2	14.7	24.9	37.2	10.0	13.1
Winter wheat	57.8	7.8	43.2	19.9	34.3	31.3	9.0	12.0

fect either. This shows that the strength properties are also governed by some other factor or that the influence of the factors considered is more complicated than supposed when introducing the algebraic sum of the so-called positive and negative properties.

When discussing the relationship between straw properties and yields and chemical composition of the pulps, attention was drawn to the lower yields and higher alpha-cellulose/pentosan ratios of the oat straw pulps and these were considered as indications of a higher susceptibility of oat straw to the two cooking recipes employed. It is quite probable that somewhat milder recipes would have yielded oat straw pulps of about the same yields and ratios as the rye straw and wheat straw pulps discussed here. It seems possible that such oat straw pulps would possess somewhat lower drainage times and somewhat better strength properties than the present ones.

Only further research into the properties of straw will be able to disclose what other factors may influence the properties of pulps prepared from it.

SUMMARY

1. Of eight kinds of straw (tetrapoid rye, rye from sandy and from peaty soils, oats from sandy, silty and from peaty soils, summer and winter wheat), the following properties were determined:

A. Percentage of internodes, nodes, ears (panicles) and leaves + sheaths.

B. Fractions of elements < DIN 70, > DIN 70 < 25, > DIN 25 < 16, > DIN 16 in potassium chlorate/nitric acid macerates.

C. Chemical composition of the parts mentioned under A. and total chemical composition, including ether solubles, water solubles, insoluble ash and protein, lignin, pentosan, alpha-cellulose, carbon dioxide from uronic acids and acetyl.

D. Stalk diameter, thickness of internode wall, number of vascular bundles, and area percentages of epidermis, sclerenchyma, and parenchyma in cross sections of internodes.

2. The straws were digested with caustic soda and with neutral sulphite liquors and the pulps submitted to three-stage bleaching; both bleached and unbleached pulps were beaten for various times in a Jokro mill and handsheets made from the beaten pulps with determination of the drainage time; the handsheets were tested for breaking length, bursting and tearing strengths, and folding number.

3. Outstanding morphological features of the eight kinds of straw are the high percentages of internodes (>60) of rye straw, the high percentage of leaves (about 40) of oat straw and the high percentages of ears (15 and 20) of wheat straw (Table I). Tetraploid rye straw is characterized by a high percentage of fraction > DIN 16 (46) and a low percentage < DIN 70 (24) in the macerate. The other end of the scale is the summer wheat straw with 25% >16 and 37% <70 (Table II).

4. The anatomical investigation yielded but little distinct variation among the straws, the main point being the lower thickness of the internode wall in oat straw (Table IV).

5. The chemical composition shows rather erratic figures for water solubles. The rye straws are characterized by low insoluble ash and high lignin contents (about 1 and 17 to 18%, respectively), the oat straw by high ether solubles and low acetyl contents (about 2 and 1½%, respectively), while the main features of the wheat straws are their high ash and low alpha-cellulose contents (about 8 and 33%, respectively). The sums of the 9 components vary between 98% and 101% (Table III (e)).

6. Total pulp yields and percentage of rejects are lower for oat straw than for the other kinds; no clear-cut differences in bleachability could be observed. The oat straw pulps also show a somewhat greater loss of cell-wall carbohydrates and a higher alpha-cellulose/pentosan ratio than the other pulps.

The insoluble ash contents of the pulps more or less parallel those of the straws, especially in the neutral sulphite pulps [Tables V (a) and (b) and VI (a)–(d)].

7. Mean drainage time was lowest for the pulps from tetraploid rye straw and highest for those from oat straw from peaty soil, the pulps from the other straws showing minor variations.

Strength properties, with the exception of folding number, generally show the highest values for the rye straw pulps, followed by the oat straw pulps from sandy and silty soils; those of the pulps from oat straw from peaty soil are somewhat lower than those of the other oat straw pulps, while the wheat straw pulps (especially those from winter wheat) show the lowest values of all (Table VIII).

8. Soda pulps show better strength properties than neutral sulphite pulps and unbleached pulps better than bleached pulps; pulps beaten for 15 min. differ from those beaten for 10 min. only in their higher mean drainage time (Table VIII).

9. From the pulp properties, two evaluation numbers were calculated according to the formula under Table VII (b), one including (I) and one excluding (II) mean drainage time (Table VIII).

On the basis of evaluation number I, the order of the pulps is — tetraploid rye > diploid rye > oats sandy and silty soils > summer wheat > winter wheat > oats peaty soil. On the basis of evaluation number II, it is — tetraploid rye > = rye peaty soil > rye sandy soil > = oats silty soil > = oats sandy soil > oats peaty soil > summer wheat > winter wheat.

10. It is shown in Table X that the lower yields of the oat straw pulps might be due to a combined influence of the chemical composition, the percentage of leaves, and the wall thickness of the internodes of the corresponding straws.

11. With regard to mean drainage time and strength properties of the pulps, it is pointed out that a certain relationship may exist with contents of alpha-cellulose + pentosan and insoluble ash, percentage internodes and ears and percentage fractions > DIN 16 and < DIN 70 of the macerates of the straws; however, certain features of the mean drainage time like the extremely high value for oat straw pulps from peaty soil cannot be explained in this way (Table XI).

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Progress in Alkaline Pulping—1957

THE INSTITUTE OF PAPER CHEMISTRY

This report continues the series (*1–11*) on the technical and topical literature reporting progress in alkaline pulping. It reviews the literature abstracted in the Abstract Bulletin of the Institute of Paper Chemistry during the calendar year 1957.

EXPANSION, MODERNIZATION, NEW MILLS

United States

Paper Trade Journal (*12*) presents a list of 75 definite and four proposed new mill and major expansion projects. Progress in the construction of the pulp and paper mills of Dierks Paper Co. at Pine Bluff, Ark., is reported (*13*). The initial production unit will produce 175 tons daily of kraft papers and linerboard. Features of the expansion program at the Jacksonville, Fla., mill of the St. Regis Paper Co. include a pulp mill, enlarged power and wood-handling facilities, and a new kraft paperboard machine which has a designed capacity of 1000 tons per day (*14*).

Evans (*15*) describes the new Palatka, Fla., mill of Hudson Pulp & Paper Co. which is the first tissue mill to operate on a 100% bleached southern kraft furnish.

The principal feature of a multimillion dollar expansion and modernization program for the Savannah, Ga., plant of Union Bag-Camp Paper Corp., is the new no. 7 machine, designed to run at a maximum speed of 2500 f.p.m. in the production of lightweight kraft papers (*16*). Other phases of the program include a hardwood pulp mill and the addition of a new lime kiln.

Turnbull (*17*) gives a description of the production of foodboards from bleached pine kraft at the Canton, N. C., and Pasadena, Tex., mills of Champion Paper and Fibre Co. Evans (*18*) discusses the process used in the new kraft pulp bleaching plant of Brown Co. at Berlin, N. H. Evans and others (*19–21*) describe some of the recent developments at the Lufkin, Tex., mill of Southland Paper Mills, Inc. They include expansion of the groundwood and kraft mills, remodeling of the bleach plant, installation of a 2700 cu. ft. Wyatt digester, and the installation of a 212-in. Pusey & Jones fourdrinier machine.

A major phase of expansion was completed with the startup of the new $2.7 million kraft pulp bleach plant at the Camas, Wash., mill of Crown Zellerbach Corp. (*22*). The plant raises the total bleaching facilities at Camas to 885 tons per day.

Two units of the plant expansion at Longview Fibre Co. now in operation are the evaporator and three-digester pulp mill extension (*23*). Units which should be completed by the fall of 1957 are a kraft recovery boiler, woodroom, bleach plant expansion, and sewage-treatment plant.

Canada

A survey of pulp and paper mill expansion in Canada in 1957 by Taylor (*24*) shows a sharp drop in expenditure on new mills compared with the 1956 survey. The various mills with expansion programs are listed along with cost, completion date, and a brief description of the program. *Pulp and Paper Magazine of Canada* (*25, 26*) summarizes the expansion and improvement programs of 25 Canadian companies in the first reference, and those of 37 mills in the second.

Price and others (*27–32*) describe various features of the new Hinton, Alb., mill of North Western Pulp & Power, Ltd. The plant produces more than 400 tons per day of bleached kraft pulp by the Kamyr continuous process from white spruce and lodgepole pine and, processed separately, from mixed hardwoods, principally poplar.

Progress in the building of the $38 million pulp mill of British Columbia Forest Products at Crofton is reported (*33–36*). The 425 tons per day bleached kraft mill is scheduled to start production in the fall of 1957.

Price (*37*) reports that a 5-year program of expansion and modernization at the Elk Falls Co., Ltd., has resulted in, among other things, a new kraft mill and bleach plant. Price (*38*) also listed the new facilities obtained through a major expansion program at the Port Alberni mill of MacMillan and Bloedel Ltd. Included were a lime kiln, recovery building, boiler house, digester extension, pulp storage tanks, and a screen and bleach plant.

Toles (*39*) describes the layout of the box plant in the new Crown Zellerbach Canada Ltd. paper converting factory in Richmond, B. C., which has a capacity of 25,000 tons per year.

Wilson and others (*40–43*) describe the recent expansion and conversion of the Dryden, Ont., mill of Dryden Paper Co., Ltd., to kraft pulp production. The $11.6 million program will double the annual production from 72,000 to 142,000 tons of quality bleached and unbleached northern sulphate pulps and kraft papers.

Many changes and improvements are going on at three mills of Minnesota and Ontario Paper Co. (*44*), among which is the installation of a kraft pulp washing system at International Falls.

Taylor (*45*) reports that the start of production of Thurso Pulp and Paper Co. at Thurso, Que., is officially set for January, 1958. The mill will be producing a high quality, high brightness bleached kraft pulp from both hardwood and softwood.

The Canadian International Paper Co. started production of bleached kraft board at La Tuque (*46*). The present aim of 15,000 tons per year is expected to be doubled within the next five years.

Europe

Waller (*47*) reviews the expansion of Skoghall Mills,

The review for 1957 was prepared by J. R. Byrne, Research Assistant, under the direction of D. J. MacLaurin, Chief, Pulping and Papermaking Section, The Institute of Paper Chemistry, Appleton, Wis.

Sweden, during the past decade which has included new vertical digesters in a new digester house, the manufacture of Cordicel in the sulphate plant, a new woodroom, research laboratories, and employee housing facilities. Paper and board production had reached 45,000 tons in 1955.

Hannunkari (*48*) reports on the expansion program started in 1954 at the Kemi Oy pulp mills in Finland which was designed to raise the annual output of the sulphate mill from 60,000 to 110,000 tons.

Australia

Younger (*49*) reports that the Maryvale mill of Australian Paper Manufacturers Ltd. is now producing 60,000 tons per year of kraft paper. The excess kraft pulp produced there is shipped to other Australian mills. The furnish is prepared from eucalyptus species growing near the mill mixed with long-fibered pulps brought in from other countries.

ALKALINE PULPING—GENERAL

Neubrech (*50*) summarizes production totals and trends in 1956 in an economic review of the pulp, paper, and board industries. Wood pulp production exceeded 22 million tons, a gain of 6.7% over 1955. Evans (*51*) points out the gains made in 1956 in raw materials, pulp production, paper, board, and converting.

Fowler (*52, 53*) reports that, in 1956, the pulp and paper industry of Canada once again broke all previous records. The over-all output was 11 million tons, nearly 6% higher than 1955. All principal grades of pulp except the dissolving and special alpha grades made sizable increases in production. Groundwood production increased by 6%, unbleached sulphite by 5%, bleached sulphate by 5%, unbleached sulphate by 20%, and soda and semichemical pulps by 16%.

Hall (*54*) predicts that the production of bleached sulphate and sulphite pulp in Finland, Norway, and Sweden will increase rapidly. Unbleached sulphate and dissolving pulps will increase less rapidly, while unbleached sulphite production will probably remain constant or decrease.

Kleinert (*55*) surveys the progress in wood pulping processes for the production of high yield pulps with special attention given to the research contributions made by the Pulp and Paper Research Institute of Canada.

Ceuterick (*56*) reports that the "Syndicat de la Cellulose Congolaise" has been created for the purpose of exploiting the immense forests of the Belgian Congo. Preliminary tests show that it is possible to obtain a pulp by the sodium sulphate method from a mixture of woods in an over-all yield of 47%. The pulp differs from the classical kraft pulp in that the drainage rate increases rapidly with beating and the pulp requires a longer treatment to reach optimum strength. Most strength properties of the beaten pulp are from 83 to 90% of those of a classical kraft pulp.

Smith (*57*) describes some of the problems encountered in kraft pulping at the Maryvale, Australia, mill. Because of a fire which destroyed much of the most desirable species of eucalypts, a large part of the wood furnish included other less desirable eucalypt species. Poor pulp, high alkali consumption, and difficulties in the evaporation and burning of black liquors are some of the problems encountered.

Drinker (*58*) reports that the experience of five mills with the Foxboro control system for direct-steaming alkaline digester relief indicates improved digester circulation, reduced liquor pull-over, uniformly low reject percentage, minimum permanganate variations, and lessened steam consumption.

Banfill, *et al.* (*59*), investigated a short-fibered alkaline hardwood pulp for the purpose of finding a stock suitable for producing papers of improved dimensional stability, strength, and formation with little treating and refining. Through improved accuracy of control methods, a tripling of the viscosity of the unbleached pulp was achieved so that it approached that of a standard paper-grade sulphite pulp.

Working under McKinney's hypothesis, Haggroth and Lindberg (*60*) treated phenyl-β-D-xylopyranoside with alkali in the presence of methanol, glycerol, amylose, or cellulose. The β-D-xylopyranosides of methanol and glycerol were obtained in good yields. If phenyl-β-D-xylopyranoside is regarded as a model for a lignin-hemicellulose complex, then these findings support McKinney's hypothesis; however, the existence of such a complex is still problematical.

Venemark (*61*) criticizes the paper by Regnfors and Stockman on the subject of the definitions of alkalinity and sulphidity. Generally accepted standardized definitions of "active" alkali and sulphidity have been used since 1954 in Canada, Finland, Sweden, and the United States. He claims that their evaluation of the question of "active" alkali versus "effective" alkali is inappropriate and incomplete. The term "alkalinity" is considered inappropriate and unnecessary for the suggested purpose.

Vroom (*62*) reports that cooking times and temperatures of any cooking cycle in kraft pulping can be treated as a single variable and represented by a single numerical value, the "H" factor. Calculation of the factor consists of obtaining the area under a relative reaction rate versus time curve. A potential use would be as a guide in adjusting a cooking cycle when operational difficulties dictate a change from standard times or temperatures.

Surewicz (*63*) defines "dangerous cooking crest" as a limit value on certain process conditions beyond which increasing the time of digestion serves only to produce pulps of higher chlorine number and decreased bleachability. In order to fix these conditions, experimental kraft cooks were carried out on pinewood at various maximum temperatures, active alkali to wood ratios, and times at maximum temperature. Other variables were maintained constant. It was found that the "dangerous cooking crest" can appear in a wide range of pulping values.

Dean, *et al.* (*64*), reports that the use of black liquor as a diluent in the makeup of cooking liquor used in pulping *Eucalyptus gigantea* produced unfavorable effects on the strength properties, yields, and bleach consumption of the pulps obtained.

Hobden (*65*) studied the mechanism of alkaline pulping using *Eucalyptus regnans* shavings. Of all factors studied, temperature had the greatest effect on pentosan removal, delignification, and loss of cellulose. Descriptions of the pulping mechanism in the form of a modified first-order reaction could be shown to apply only to a limited part of the reaction.

Prey (*66*), after studying the mechanism of alkaline digestion, reports that five groups of chemical reactions occur—dissolution of the hemicellulose, dissolution of the lignin, degradation of hemicellulose, degradation of lignin, and degradation of the cellulose. The first reaction consumes about 12% of the alkali, and the main reaction (dissolution of the lignin) merely 4%. The behavior of the hemicellulose under alkaline digestion conditions was investigated in detail.

Bannister, *et al.* (*67*), report that, by using certain techniques, kraft knots and screen room rejects have been successfully refined and bleached without recooking. The strength properties of the resultant pulp are only slightly affected by the small amounts of screenings added.

Kanda and Matsumoto (*68*) determined the amount of phenolic hydroxyls in the lignin of alkaline pinewood pulps and related it to the color of the unbleached pulps. Low-lignin pulps generally contained more phenolic hydroxyl groups than did pulps of higher lignin contents.

Migita and associates prepared a series of studies on the color of sulphate pulp. To study the effect of color of the cooking liquor (*69*), sulphate digestions were carried out with kraft cooking liquor containing some black liquor and with cooking liquor renewed half way. The color of the liquor had some effect, especially in the initial phase of digestion. The color of the pulp may be attributed to the presence of lignin, carbohydrates, and their decomposition products in the cooking liquor; however, digestion with water of pH 7 containing xylose-decomposition products had little effect on pulp color. Pulp color is also affected by the time used to preheat the charge to maximum temperature (*70*). The shorter the preheating time, the deeper the color. Four samples of pinewood meal, differing in lignin contents, were cooked by the alkaline process (*71*). The brightness first decreased, then increased, and finally decreased again, whereas their color purity first increased, then decreased, and finally increased again almost at the same time as the brightness decreased again.

Jayme, *et al.* (*72*), report on the discovery of a hitherto unknown type of pulp, designated as "biological" pulp. Such pulps are characterized by developing in the unbeaten state abnormally high strength properties. Another previously unknown behavior is the initial strong decrease of folding strength during beating in a Jokro mill prior to the customary slow increase.

Ayer (*73*) determined the effect of toxicant addition on the physical strength, freeness, and microbiological count of southern pine kraft pulps in high density storage. The samples were tested after 3, 7, 10, 14, and 17 days' retention. Results indicated that neither retention nor toxicant affected the maximum strength attainable. Retention had no effect on beating time with the sample having the highest percentage of toxicant, but reduced it as much as 25% with the two samples containing lesser amounts.

Ayer, *et al.* (*74*), subjected a southern pine kraft pulp to high-density storage for 2 weeks in the presence of microorganisms. It resulted in a decrease in alpha-cellulose and a corresponding increase in the beta-cellulose fraction. Lignin content remained constant. The disperse viscosity increased with increasing time of storage. Except for fold which increased, the strength properties were unaffected.

THE COOKING PROCESS

Correns and Jacopian (*75*) report that as a result of experiments carried out to relate the dissolution of pentosans and lignin to the consumption of alkali during the different phases of digestion of normal and prehydrolyzed beechwood, a new two-stage alkaline dissolving process has been derived which produces pulps at 25 to 30% savings of alkali.

Fukuda and Mizukami (*76*) compared the properties of a soda pulp from Japanese spruce with a kraft pulp prepared from the same wood. Compared at the same yield, the properties of the soda pulp were much inferior. The reason for the extensive degradation of cellulose during the later stage of soda pulping is probably due to the cellulose being exposed to stronger effective alkali for a longer period of time at high temperature.

Wultsch (*77*) describes and discusses critically various semichemical pulping processes including the neutral sulfite, sulphate semichemical, cold soda, and Delbay process.

Sobolev, *et al.* (*78*), report that, compared to a normal soda cook, an alkaline cook with simultaneous hydrogenation gives a somewhat brighter pulp of identical viscosity and produces a purer lignin fraction of lower molecular weight.

Trobisch (*79*) found through experiments in water-prehydrolysis sulfate pulping that the total prehydrolyzate need not be discarded but may be added to the cooking liquor with resulting benefit to both yield and alpha-cellulose content.

Korchemkin (*80*) found that prehydrolysis of wood chips causes the disintegration of the outer cell wall, thus making kraft pulp obtained from the chips more reactive and suitable for conversion to viscose.

Fukuda and Yamashita (*81*) compared Japanese spruce shavings cooked by the prehydrolysis sulfate process to those cooked by the regular sulfate and sulfite processes. During prehydrolysis, water selectively hydrolyzed and partly extracted the wood hemicelluloses whereas cellulose and lignin remained unchanged. Better yield and quality may be obtained by finding a way of removing part of the lignin during prehydrolysis.

Surewicz (*82*) studied the effect of temperature, time, active alkali to wood ratio and chemical composition of the liquor in the manufacture of hard sulfate pulps.

Christiansen, *et al.* (*83, 84*), present data to show the effect of sulfide on the alkaline cooking of western red cedar. There does not appear to be an upper limit of sulfide charge beyond which there is no additional effect of improved yield and strength properties. However, at some value between 3 and 5% sulfide, the effects of additional increments are small and difficult to gage.

After a discussion of the various factors affecting the cooking time of kraft pulp, Rosenberger (*85*) presents some Russian experiences and experiments on accelerated kraft cooking.

Kitao and Koshijima (*86*) present results of kraft pulping trials on 20 Japanese hardwood species of Yakushima Island. Unbleached kraft pulps were obtained in yields ranging from 43.5 to 56.8% unscreened; per-

manganate numbers varied from 5.0 to 18.2, and relative viscosities in 0.4% cuprammonium solution from 4.8 to 9.4.

Kitao and Togo (*87*) determined the amounts of ray and parenchyma cells in kraft pulps from 22 Japanese hardwoods of the Hokkaido District. They contained from 2.8 to 18.3% of ray and parenchyma cells.

Laviste (*88*) discusses the use of hardwood kraft pulps as a substitute for softwood pulps and mentions that softwood cannot be replaced 100% when manufacturing newsprint. The properties of pulps made from hardwoods by various processes are described.

Seidl (*89*) discusses the various types of processes suitable for pulping hardwoods and comments on the position of hardwood pulp specifically in producing boards, news, printing grades, and specialty papers.

Tachi, *et al.* (*90*), report that kraft pulping a mixture of hardwood and softwood does not seem possible where maximum strength and optimum pulp quality are desired because maximum strength in softwood kraft developed at approximately 10% lignin content and in hardwood at about 2% lignin content.

Hopner (*91*) pulped six tropical wood species by the kraft process at a series of temperatures. The D.P.'s of the pulps showed significant differences at 140°C. which became gradually smaller with prolonged digestion at higher temperatures. Mixtures of different wood pulps can be compared with pulp from a single species, which can be considered a mixture of spring and summerwood. Most properties of 1:1 mixtures of pulps having contrasting structural characteristics could be predicted closely from statistical calculations.

Kimura and Teratani continued their studies on pulp and papermaking. White birch was cooked with a mixed solution of sodium sulfite and sodium sulfide in an attempt to prepare a strong high-yield pulp (*92*). At sulfide ratios above 50%, a pulp having favorable mechanical properties was obtained in 66 to 70% yields. At lower sulfide ratios, the viscosity of the pulp decreased greatly, but the mechanical properties decreased only slightly. Japanese red pine was also cooked in the same type of liquor (*93*). Strong unbleached pulp equivalent to chemical kraft pulp can be obtained by this process in yields of 60–72%.

Flamm and Bellak (*94*) found no significant differences in the kraft pulps of larch and pinewood in respect to yield, cooking degree, or physical properties.

Kayama (*95*) evaluated the effects of blue stain on the pulping properties of Japanese red pine by inoculating the wood with certain cultures and then pulping the wood by the sulfate process. The blue-stained wood was higher in ash, pentosan, and lignin but lower in extractives and especially in cellulose than the sound wood.

Staffa (*96*) investigated willow as a raw material for pulp and paper. When cooked by the kraft process, yields from 47.7 to 60.1% were obtained; the physical properties and quality of the pulp are satisfactory for a hardwood pulp.

Theiss (*97*) discusses the utilization of birchwood in the pulp and paper industry. It is used for the production of sulfate, sulfite, and semichemical pulps which are essentially as strong as sprucewood pulps. Birchwood kraft is particularly suited for twine and bag papers but not for cable papers.

Clark (*98*) reports on the sulfate pulping of cottonwood at the Simpson Paper Co., Everett, Wash. The process produces an easy-bleaching pulp which is processed in a four-stage continuous bleaching plant alternately with softwood pulp before being combined to make the papermaking stock. One of the difficulties encountered in the use of cottonwood is the occurrence of calcium carbonate in the pulp.

Krach and Lang (*99*) evaluated *Melitotus officinalis* for the pulp industry. Trial kraft cooks with 19.9% active alkali for 3 hr. at 160°C. gave a pulp yield of 48–49%. The wood can be used as a raw material but, because of its relatively low strength properties, it should be used in blends with other pulps.

Jayme and Semmler (*100*) investigated black locust wood in regard to the production of tannins and pulp. A kraft pulp of moderate strength was obtained in about 50% average yield. Strength values remained approximately the same when pulping was preceded by hot-water extraction.

Koshijima, *et al.* (*101*), studied the pulping properties of *Metasequoia glyptostroboides* in comparison with those of *Pinus densiflora* and *Cryptomeria japonica*. Specific gravity, lignin content, permanganate number, and fiber-length data are presented.

Koshijima and Kitao (*102*) studied semichemical pulps of shirakashi wood prepared by the neutral sulfite, kraft, and acid sulfite processes. Unbleached pulp yields were 70, 66.5, and 61%, respectively. Strength differences between the unbleached pulps disappeared after bleaching, and the strength of the bleached pulps was 20 to 60% higher.

Watson (*103*) prepared soda pulps from the tension-wood and normal wood of *Eucalyptus goniocalyx* and *E. regnans*, and compared the yields and properties. The tensionwood gave much higher yields, but the strength properties were lower than those of the normal wood. This is attributed to the lower hemicellulose content and to the thicker cell walls of the tensionwood which result in poorer fiber-to-fiber bonding.

Lewin and Lengyel (*104*) prepared a sulfate pulp from Israeli *E. rostrata* in a screened yield of 50 to 51%. The physical properties of the pulp make it particularly suitable for printing and fine papers.

Adamson and Chidester (*105*) report that high-quality printing papers can be produced from Philippine bamboo by a one-stage sulfate process. Wrapping and bag papers from the unbleached pulps compare in bursting strength with southern pine kraft.

Jayme and Rosenstock (*106*) obtained a very bright and easily bleachable pulp of satisfactory properties from depithed bagasse using the water-prehydrolysis sulphate process. On xanthation, the bleached pulp yielded a very clear viscose without fiber residues, indicating that raw bagasse can be used for the production of high-quality dissolving pulps.

Hinrichs, *et al.* (*107*), applied prehydrolysis, controlled chemical addition, and use of a hydrotropic solution as cooking liquor to the pulping of Hawaiian bagasse. Prehydrolysis before alkaline pulping led to lower strength, lower yields, and greatly increased chemical requirement. With controlled addition of an alkaline chemical longer cooking times were required, pulps were rawer, and yield was lower. Hydrotropic pulping using

a concentrated solution of sodium xylenesulphonate gave pulps with lower strength and brightness.

Knapp, *et al.* (*108*), studied the typical variations in the origin and preparation of bagasse for pulping. Four sugar-cane varieties in Hawaii displayed only minor differences when pulped. Leafy material present, pith, field dirt, and aging were all studied. It is concluded that removal of all nonfibrous constituents in bagasse is an essential first step in producing bleached pulps.

Knapp and Wethern (*109*) studied the alkaline pulping of bagasse. A pulp can be obtained using cooking times as short as 2 min. at 340°F., at a yield of 55 to 60% with a permanganate number of 7 to 9. Strengths obtained are moderate.

Chittenden and Morton (*110*) pulped rice straw by the sulfate process. It was found that pulp produced using 10% effective alkali and 20% sulphidity and subsequently bleached in a single stage process has properties similar to those of a commercial bleached wheat-straw pulp. Paper from this pulp would be suitable for printing, writing, and light wrapping.

Milchová (*111*) studied rice straw as a possible supplementary pulp source in Czechoslovakia. Best results were obtained by the sulphate process followed by a two-step chlorination. Although the rice straw produced in the country is well suited, the amount available is too small to justify the construction of a mill.

Iwanow (*112*) reviews and contrasts various straw-pulping processes, including sulfate. He then illustrates some of the characteristic properties of straw pulps.

Iwanow (*113*) reports on a recently developed semi-hydrolysis process which, when followed by kraft pulping, produces a satisfactory pulp from reed. Using a reed:liquor ratio of 1:1, the digester is first heated to 110–120°C. as fast as possible, then degassed, heated to 150–160°, and left at this temperature for 1 to 2.5 hr. Cooking liquor is pumped in and the charge is heated to 170° and kept there until the end of the cook.

Bhat and Singh (*114*) experimented with the sulfate cooking of twisted chir and found the pulp to be suitable for making wrapping paper.

Chittenden and Morton (*115*) subjected six samples of sedges and rushes from Northern Rhodesia to pulping by the kraft process. An excessive proportion of stronger pulp would have to be mixed with the resultant pulp to produce acceptable wrapping or fine paper. It is possible that a semichemical process would be more successful.

Isa (*116*) cooked rapeseed stalks by the sulphate process using 26% sulfidity and 25% total alkali and obtained an easily bleachable pulp in 43% yield. The pulp lends itself to wet beating and is as strong as hardwood pulp.

Marchlewska-Szrajer (*117*) reports on experiments carried on at the Polish Pulp and Paper Institute to test the suitability of nonwoody plants for pulp manufacture. Results indicate that, with the exception of hay grown in marshes and flax sheaves, the plants tested are suitable as raw materials for paper.

Enkvist, *et al.* (*118*), report that laboratory digestions of pinewood with sodium hydroxide solutions containing various reducing agents did not show any advantage of the reducing agents, compared with the effect of sulfides normally used in sulfate pulping.

Yllner and Enstrom (*119*) studied the absorption of xylan on cellulose fibers which occurs during a sulfate cook. Results of experiments show that extensive xylan adsorption requires both elevated temperatures and the consumption of most of the alkali. It is suggested that the "adsorption" is in reality a crystallization.

Enkvist, *et al.* (*120*), reports that potentiometric titration of the black liquors from sulfate digestions of sprucewood showed that the consumption of alkali roughly parallels the dissolution of carbohydrates from the wood. After this has stopped, the dissolution of lignin alone is accompanied by only an insignificant alkali consumption. The consumption of sulfide sulfur during sulphate digestions is relatively low.

McGovern (*121*) discusses some of the developments in rapid continuous pulping. Mechanical and physico-chemical problems have largely been solved. Commercial use of continuous pulping has reduced production time from 3 hr. to 20 min. for bleachable kraft pulp. Pulp quality is maintained or improved.

Nolan (*122*) studied the effects of chip size and pre-impregnation on pulps produced by continuous kraft pulping of slash pine. Preimpregnation will reduce the cooking time but also the yield and quality of the pulp. Mill-size chips, with or without impregnation, cannot be converted by high-speed pulping methods to pulps of good yield and quality.

Fineman (*123*) tracked the course of three radioactive wood chips through a Kamyr continuous digester during an alkaline cook. Although the three chips were located at different parts of the digester cross section, they moved with identical velocities. The pulp column in the lower fifth of the digester rotates in the same direction as does the discharge mechanism and at a velocity which increases downward and reaches about one third that of the scraper at the bottom.

Obenshain (*124*) obtained a patent for a continuous process for producing pulp which utilizes a liquor having an input concentration of 20 g.p.l. or less of sodium oxide which is circulated through the digester at 10 to 100 times the rate of chip flow.

Rosner (*125*) describes the Muskau process, invented by Offermann, which makes it possible to manufacture semichemical and chemical (alkaline) pulp with good bleachability from annual plant residues and wood waste.

WASHING AND SCREENING

Weiters (*126*) discusses the performance of a three-stage screw-press system for washing kraft gum pulp. Actual washing results are close to theoretical; highest discharge consistency will produce the best results. Other conclusions include the following: variable speed drives for press worms are desirable; unprotected mild steel is not satisfactory for press plate surfaces; and hardwood pulp stock is corrosive and abrasive in the screw press system.

A brown stock washer installed at the International Falls mill of Minnesota and Ontario Paper Co. comprises a series of pipes 120° apart which spiral from inlet to outlet (*127*). The vacuum developed inside the spiraling tubes draws the dilution and shower liquor through the stock.

In an attempt to shorten the washing time, Strunnikov and Slyatskii (*128*) introduced certain modifications in the construction of diffusers. From these changes and from theoretical considerations of the effect of various factors on the rate of filtration, it was concluded that the most important factors are the thickness of the filtration layer and the degree of its compression.

Dedert and Waters (*129*) evaluated various methods of measuring brown-stock washer efficiency. It is concluded that most mills can profit from close daily supervision of their pulp-washing facilities.

Calhoun, *et al.* (*130, 131*) discuss refinements in equipment and in installation methods and improved operating techniques which have eliminated many of the differences in capacity of pulp and in washing efficiency regardless of the type of cook.

Willins and Elder (*132*) made a screening-rate investigation to find optimum screening conditions for a kraft stock containing a high percentage of Douglas-fir fiber on Lindblad screens. The use of chrome plates, 6 by 0.014 in., gave the largest increase (41%) in screening rate of the plates tested. The chrome plating is credited with 25% of the increase, the other 15% is credited to a reduction from 10 to 6 cuts per in.

THE LIQUOR CYCLE

Continuing the review of research done at the Kolningslaboratoriet since its beginning, Bergstrom (*133*) surveys investigations on by-products and spent liquors of the sulphate process.

Sconce (*134*) reviews four papers presented at the 36th annual national convention of the American Institute of Chemical Engineers. Two authors and titles of interest are: James G. Coma, "Dimethyl Sulfide Production from Kraft Pulp Mill Black Liquor"; and Robert E. Florine, "Economic Planning of Kraft Mill Evaporators."

Bories (*135*) discusses the Torras-Xucla and Laguilharre methods of concentrating black liquor and recovering high-pressure steam and energy. The Torras-Xucla method gives a solid combustible product by precipitation and subsequent filtration. It favors steam production and dust removal. The Laguilharre method cools the flue gases to about 65°C. and permits partial condensation of water vapor. It can replace the economizer, the dust remover, and also the multistage evaporator in part.

Werenskiold (*136, 137*) relates experiences in the recovery of spent liquor, evaporation, use of recovery furnaces, recovery boiler research, use of precipitators, instrumentation, scrubber towers, and wet combustion of black liquor in Europe.

The chemical recovery system at the new British Columbia Forest Products bleached kraft pulp mill at Crofton, B. C., is described (*138*). Sundholm and Back (*139*) report that a Babcock and Wilcox–Tomlinson chemical recovery unit at Mofors paper mill has been rebuilt to increase its capacity from 80 to 110 tons of sulphate pulp per 24 hr. without reducing the unit's efficiency.

Gray, *et al.* (*140*), obtained a patent for a process in which kraft black liquor is carbonated with carbon dioxide at a pressure of 20 to 165 p.s.i. at a temperature below 70°C., and hydrogen sulphide is stripped from the carbonated liquors under a vacuum. The stripped liquor is heated to agglomerate the lignin, the liquor is cooled, and the precipitate is filtered out, producing a relatively pure alkali lignin.

Barton and Schoeffel (*141*) obtained a patent for a cooking process which employs a recovery cycle which requires little make-up. The spent liquor and pulp washings are mixed and oxidized at 150 to 372°C. and 400 p.s.i. with sufficient oxygen to convert carbon to carbon dioxide and hydrogen to steam; the effluent is then agitated at 85° with calcium oxide to precipitate calcium carbonate. The filtrate is sodium hydroxide suitable for recycling to the digestion step.

In a similar patent by the same authors (*142*), the filtrate obtained after treatment with calcium oxide is mixed with barium sulfide to precipitate barium sulfate and provide a filtrate containing sodium hydroxide, sodium carbonate, sodium sulfide, and sodium sulfate suitable for recycling to the digestion process.

Domansky (*143*) developed a new method for determining sulfide in black liquor by applying to black liquor samples the potentiometric titration procedure of Willard and Fenwick. The new method gives values 6% higher, because a considerable loss of hydrogen sulfide occurs in the standard method.

Strickland and Risk (*144*) applied the Lauth violet absorptiometric sulfide determination to weak black liquor and compared results with those obtained with the Borlew and Pascoe procedure. The agreement between the two tests was good.

Kesler (*145*) presents a method of analysis for the determination of sulfide, sulfite, thiosulfate, and polysulfides in neutral sulfite white liquor, kraft white liquor, and solutions of recovery furnace smelts which is based on the use of iodine and hypoiodite as volumetric oxidizing agents.

Badger and Lindsay (*146*) present a review of the literature published on evaporation during the past year.

Owens (*147*) obtained a patent for a means for controlling an evaporator in which the liquor is evaporated in direct contact with hot waste gases. It consists of one set of dampers which can divert hot gas directly to the evaporator and another set of dampers which control the length of time the gases remain in the evaporator and the duration of gas-liquor contact therein.

Lockman and Jenssen (*148*) received a patent for a modification of the conventional method of circulating condensates from the first to the last stages of evaporation which will permit more efficient recovery and reuse of the heat in the condensate system.

Rusch (*149*) discusses the advantages of cleaning black liquor evaporators and mentions that the principal advantages of modern chemical cleaning methods over older mechanical and alkaline cleaning methods are greater speed and thoroughness, with consequent reduction in down time.

Hochmuth (*150*) obtained a patent for an improved recovery furnace bottom which permits efficient drainage of the hot smelt without destruction of the furnace bottom through corrosion or erosion.

Miller (*151*) discusses a few of the routine maintenance problems which occur during normal operation of a black-liquor recovery furnace.

A Buffalo Forge fog-type scrubber is being used by Mead to eliminate soda ash snow from the recovery furnace stack at Kingsport (*152*). Effluent from the

scrubber is being used in the continuous causticizing plant as part of the wash water for the mud washer.

Kubelka and Votoupal (*153*) describe flue gases from recovery units as the main source of chemical losses in a kraft mill. They include flue ashes which consist of sodium sulfate and small percentages of sodium carbonate. The ratio of sulphur to sodium losses in flue gases has a great effect on the sulfidity of the white liquor. Chemical balances for the hot and normal operation of recovery units are discussed.

Kubelka and Hojnos (*154*) discuss the reduction of sodium sulfate to sulfide in kraft recovery units. The reaction occurs in two steps in which carbon monoxide and dioxide are formed, respectively. Reactions proceeding parallel with the reduction can cause sulfur losses up to 40% and formation of sodium carbonate and hydrogen sulfide. These reactions can be suppressed by increasing the temperature and adding sodium carbonate.

Jemson (*155*) describes the design and operation of various pieces of black liquor recovery equipment including a recovery boiler, cyclone evaporator, multiple-effect evaporator, electrostatic precipitator, and a saltcake storage and conveying system.

Thilmany Paper Co., Kaukauna, Wis., has recently installed a "homemade" heat recovery system to save some of the heat in the recovery furnace stack gases (*156*). The system was built largely from material at the plant.

Beaver (*157*) describes the application of continuously acting electronic feedback circuitry to monitor kraft mill precipitator operation. A newly developed electronic feedback control system controls precipitator power input for the three most common operating conditions—those under which either the current, the voltage, or the sparking rate may be limited.

Wright (*158*) discusses the recovery of sodium chloride from recovery systems of kraft mills which use pulp logs which have been floating in sea water. Washing the recovered saltcake with water was examined and a saltcake/water ratio of 3:2 was estimated as best. The most serious defect of the process is the rather serious loss of sodium carbonate.

Lawson (*159*) describes a hot air economizer, dissolving-tank heat-recovery system which effects a recovery of 3.8 million B.t.u. per hr. from a 200 ton per day kraft mill by reducing the exhaust vapor temperature from 192 to 176°F. The possibilities of recovering an additional 4.3 million B.t.u. by reducing the vapor exhaust temperature to 130° are considered.

Ehrnrooth (*160*) reports that attempts to further purify white liquor from Dorr clarifiers using three different hydracyclones indicated that separation of 50 to 70% of the dirt particles is possible but that the extent of clarification depends greatly on the character and size of the particles. Silica, iron sulphide, and carbon are not separated by hydracyclones.

Trobeck and Bergstrom (*161*, *162*) obtained patents for a process in which it is claimed that the corrosiveness of kraft process liquors is lessened by reducing the sulfidity of the liquors from 30–40% to 20–25% by air oxidation. The oxidation treatment can be used on the black liquor before evaporation, on the green liquor from the furnace, or on the white liquor. By using this process, a more uniform pulp is claimed since the sulphidity of the white liquor can be kept constant by completely oxidizing a portion of the green liquor and mixing it with untreated green liquor before causticizing so that the resultant white liquor will have a sulfidity of 20 to 25%.

Allen and Coulter (*163*) obtained a patent for an apparatus for oxidizing black liquors. The liquor is passed through a tower in a plurality of films in countercurrent surface contact with the oxidizing gas. The liquor films are formed at the top of the tower in a manner that avoids the passage of oxidizing gas through any body of liquor.

Kooistra and Cobb (*164*) obtained a patent for a residual liquor oxidizing means in which the liquor passes downward while being formed into films on a number of closely spaced vertical screens. Air is passed upward between the screens.

Copenhaver, *et al.* (*165*), received a patent for a chemical recovery method in which black liquor concentrated to a 25 to 60% solids content and acidified with sulphuric acid is subjected to extraction with a combination of solvents suitable for avoiding the formation of an emulsion and giving good phase separation. Recoveries of about 95% of the acetic and formic acid contents are obtained.

Sandborn and Stengle (*166*) obtained a patent for a process for recovering the sodium salts of certain organic acids from black liquor concentration by dissolving the sodium salts with a solvent and filtering off the residue which is then passed on to conventional recovery processes. This process is improved (*167*) by utilizing methanol as the solvent and by including an additional step in which the methanol solution is mixed with an additional solvent, such as *n*-butanol or isopropyl alcohol.

Pearl (*168*) discusses the incentives to the chemical utilization of the wastes from the chemical pulping industry and summarizes some of the chemicals produced and their applications.

Based on annual production and consumption figures for whole and refined tall oil from 1935 to 1955 (*169*), the supply of tall oil was expected to reach 1 billion lb. by 1958. Production of whole tall oil was 550 million lb. in 1955. Based on increasing kraft pulp capacity, the national whole tall oil potential may reach 1550 million lb. in 1975.

Forbath (*170*) describes Union Bag-Camp Paper Corp.'s tall oil vacuum distillation plant recently built at Savannah, Ga. The plant handles up to 2000 tons per month of crude tall oil.

Hagglund and Enkvist (*171*, *172*) obtained U. S. and Canadian reissue patents on a method of producing methyl sulfide in which sulfate black liquor is heated in the presence of a substance containing inorganic sulfidic or hydrosulfidic sulfur at 150 to 500°C. The residual black liquor may be subjected to combustion as in the conventional sulfate process.

STREAM AND AIR POLLUTION

Zielinski (*173*) presents the new developments in the biological purification of kraft mill effluents.

Chadeyron (*174*) views the problem of black liquor disposal from the standpoint of both the mill and legislative bodies. Stream pollution loads of typical kraft mills are analyzed, and the important role of

laboratory research in devising adequate tests and water-purity criteria is emphasized.

Sullins (*175*) describes the methods used by the Kingsport Division of The Mead Corporation to reduce the suspended solids content, black ash char, and B.O.D. of the effluents. Satisfactory results have been obtained by treating individual effluents or groups of effluents separately.

Bacon (*176*) reports that more than $33 million have been spent in the past 10 years by the pulp and paper industry to protect receiving waters and to prevent pollution. The methods used include outfalls, lagoons, burning, chemical recovery, and by-product utilization.

Brebion, *et al.* (*177*), investigated the toxicity to fish of phenols present in the degradation products of lignin. It was concluded that the toxicity of various fractions of black liquors is not due to phenols, fractions not containing phenols being the most toxic. Synthetic phenolic compounds tested were nontoxic or only slightly toxic.

Tomlinson and Ferguson (*178*) describe the principal odor abatement measures employed at the alkaline pulp mill of Howard Smith Paper Mills Ltd. at Cornwall, Ont., which are condensation and cooling of the blow and relief steam in a two-stage system together with 100% oxidation of the weak black liquor prior to evaporation. Operation of the recovery furnace with adequate excess air to insure complete combustion, and scrubbing of the furnace gases with oxidized liquor are considered necessary.

Byrd and Dewey (*179*) present performance data on the Pease-Anthony Venturi scrubber at Procter and Gamble Co. The performance checked well with pilot-unit tests on which the design of the full scale units was based.

Gaudette (*180*) describes the construction and operation of the Cottrell Electrostatic Precipitator. Specially designed precipitators are used to recover sodium salts from gases leaving black liquor recovery furnaces. Efficiency of removal ranges from 90 to 98%.

BLEACHING

White (*181*) discusses the different bleaching processes used with various types of pulps. Sulfate pulp is typically bleached by a multistage process involving one or more chlorinations, hypochlorite treatments, and chlorine dioxide bleaches, with alkali extractions between stages. The advantages and disadvantages of the various agents and processes are described, and the difference between chlorine substitution and oxidation processes involved is pointed out.

Hinrichs, *et al.* (*182*), applied conventional bleaching methods to bagasse pulps obtained from modified kraft, soda, and neutral sulfite cooks. Kraft pulps were also bleached by the chlorine dioxide and peroxide methods. Kraft pulps were the most suitable for bleaching and gave high brightnesses with all processes except peroxide.

Fennell (*183*) obtained a patent for a multistage bleaching process for kraft pulp which obtains maximum final brightness by critical control of total alkalinity of intermediate caustic extractions.

Bate, *et al.* (*184*) obtained a patent for a purification process which includes heating the crude cellulose for 30 to 90 min. at 125 to 170°C. with 5 to 15 times its weight of a 0.25 to 1% free SO_2, bleaching with hypochlorite, subjecting the bleached cellulose to the action of 10 to 20% NaOH solution, and boiling with a 0.25 to 2% NaOH solution.

Ogawa and Jodai (*185*) determined the D.P. distribution of bleached kraft samples. The distribution curve of chlorite-bleached samples resembled that of the original semibleached pulp, whereas hypochlorite bleaching caused considerable degradation of the higher D.P. fractions.

Fennell (*186*) obtained another patent for a process in which prechlorinated kraft pulp is subjected to a hypochlorite treatment for partial bleaching and then to a peroxide stage for completing the bleaching.

Freedman (*187*) studied the effects of calcium hypochlorite and chlorine dioxide as last stage bleaches on the properties of poplar and hardwood soda pulps. Chlorine dioxide-bleached pulps attained higher brightnesses, exhibited better bulk and opacity values, and retained more of the brown stock strength.

Wilson and Wayman (*188*) investigated various chlorine dioxide bleaching sequences for sulfate pulp and because of high brightness, good strength properties, and low bleaching and capital costs, one sequence-chlorination, extraction, hypochlorite, extraction, and chlorine dioxide (CEHED) was chosen for further work.

Jensen, *et al.* (*189*), studied the chlorine dioxide bleaching of a birch sulfate pulp prebleached to a Hunter brightness of 78%. Brightness tended to reach a maximum at 86 to 88% after 3 to 4 hr. of bleaching at 60°C. with 0.3 to 1.0% ClO_2. With 0.6% concentration, the maximum brightness increased from about 85% at 40° to about 89% at 70°. Using 0.2 to 0.3% ClO_2, about the same degree of brightness (86%) was obtained in 3.5 hr. at 50°, 3 hr. at 60°, or 2.5 hr. at 70°.

Collins (*190*) describes the kraft pulp bleaching operation at the Crossett Co. One of the conclusions drawn after more than 1.5 years of operation is that good quality bleached pulp in a brightness range of 86 to 88 can be obtained from southern pine kraft pulp in a four-stage system by using chlorine dioxide in the final bleaching stage.

Robinson and Beck (*191*) describe the bleaching operation at the Evadale, Tex., mill of East Texas Pulp & Paper Co. which produces 300 to 350 tons daily of bleached softwood and hardwood kraft pulp and bleached board of 88 to 90 G.E. brightness. The bleaching sequence involves five stages—chlorination, extraction, two sodium hypochlorite stages, and chlorine dioxide. A final hydrogen peroxide stage is also being considered.

Heine (*192*) reports that among new du Pont chemicals and processes of interest to the papermaking industry is a new five-stage peroxide bleaching system for kraft pulp.

Brightness, yield, and strength results are reviewed for peroxide versus hypochlorite bleaching in one-stage treatment and for multistage hypochlorite treatment of various wood pulp types (*193*). Typical bleaching formulas are also given.

Lewis (*194*) presents a nomograph whereby the percentages of sodium peroxide and of hydrogen per-

oxide bleach liquor residual can be determined from a scale of milliliters of 0.1 *N* sodium thiosulfate and a scale of the consistency of the pulp slurry.

McEwen, *et al.* (*195*), obtained a patent for a process wherein a pulp is partially bleached with hypochlorite to a brightness of 65 to 85 and then bleached to completion with alkaline hydrogen peroxide. The final bleaching period is 1 to 20 days.

Raaka, *et al.* (*196*), studied the reversion of hydrogen peroxide-bleached kraft pulp as related to several process variables, namely, temperature, time, pH, peroxide concentration, and consistency. All variables, except consistency, were noted to have a definite effect in the development of brightness stability. A single-stage peroxide bleach was found to be effective in reducing the reversion encountered in untreated pulp up to 84%.

DIGESTER CORROSION

Smith (*197*) reports that current data from 21 mills covering 162 digesters give corrosion rates considerably lower than those reported in the "First Report—Regional Digester Activity." The average corrosion rates found in the current data correlate very closely with those reported in previous studies. This is attributed to better data and representation of most mills included in earlier surveys.

Hopper (*198*) reports that at the Covington mill of West Virginia Pulp and Paper Co. corrosion was remedied satisfactorily by the application of welded-on stainless steel overlays in the thinned areas.

Adams, *et al.* (*199*), found that a studded liner that is inexpensive, easy to install, and protects by allowing the corrosive action to be expended on its inexpensive and easily removable metal was the answer to the problem of sulphate digester corrosion.

Mueller (*200*) proposes a hypothesis for the mechanism of corrosion by kraft liquor and the action of depolarizing agents. It explains how the corrosion is stopped at a certain phase of the cook when the depolarizing current exceeds the corrosion current and the potential shifts to the passive range. It is shown that oxidation of black liquor before mixing with white liquor increases the depolarizing effect and the corrosiveness in mixtures of a low black: white liquor ratio.

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Instrumentation Studies. LXXXV. A Study of Photoelectric Instruments for the Measurement of Color: Reflectance and Transmittance

XII. The Elrepho (Photoelectric Reflectance Photometer)

LEONARD R. DEARTH, WAYNE M. SHILLCOX, and J. A. VAN DEN AKKER

The Elrepho (Carl Zeiss of Oberkochen, Germany) is a photoelectric meter, equipped with a number of narrow-band filters for the measurement of spectral reflectance of solid surfaces (such as pulp and paper). The instrument is equipped with an integrating sphere (Ulbricht), which results in reflectance data that are relatively insensitive to surface characteristics; the sphere geometry has the further advantage that diffuse reflectance is most appropriate for applications of theories (such as the Kubelka-Munk theory) of the scattering and absorption of light. However, this geometry is sufficiently unlike that of the CIE system, on which standard brightness is based to yield "blue reflectance" which is numerically different from standard brightness. In most cases, standardization through the "specific calibration procedure" permits use of the Elrepho for the evaluation of the brightness of pulp and paper. The instrumental response is independent of variations in line voltage and frequency, even when such variations are large. The specimen holder and aperture are located at the bottom of the sphere, which minimizes the amount of dust and debris that enters the sphere. The specimen holder is designed to enable convenient handling of large sheets. The Elrepho is photometrically accurate and has excellent sensitivity. A compensator is provided to permit adjustment of the linearity of response. The instrument is direct reading. The measured effective wavelength of the instrument is not the proper value for determination of standard brightness, but the correct effective wavelength could be attained through use of a suitable filter, as shown in this report. The instrument has a water-cooled jacket around the lower portion of the sphere to prevent excessive heating and to minimize the aging of the sphere lining. The user of the instrument should keep in mind that changes in the uniformity of reflectance and the color of the sphere lining affect the geometry and spectral response of the instrument. Variations in illumination from the sphere wall can cause appreciable changes in the reflectance of pulp, paper, and other materials whose goniophotometric surfaces differ from the true spherical shape of an ideal diffuser. While errors resulting from nonuniformity of illumination from the integrating sphere wall can be kept small through proper maintenance of the sphere lining, gradual accumulation of fine particles from the atmosphere could result in sufficient variability of sphere wall reflectance to cause error.

OVER the years, an increasing emphasis has been placed on the brightness of pulp and paper. Numerous reflectance measuring instruments based on various principles have been made available to the paper industry.

The Elrepho (Photoelectric Reflectance Photometer), manufactured by Carl Zeiss, Oberkochen, Germany, is the twelfth reflection meter studied on the American Paper and Pulp Association's instrumentation program

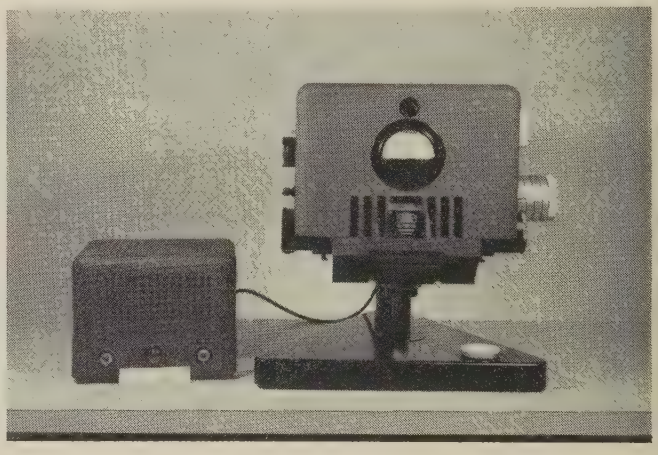

Fig. 1. The Elrepho (photoelectric reflectance photometer)

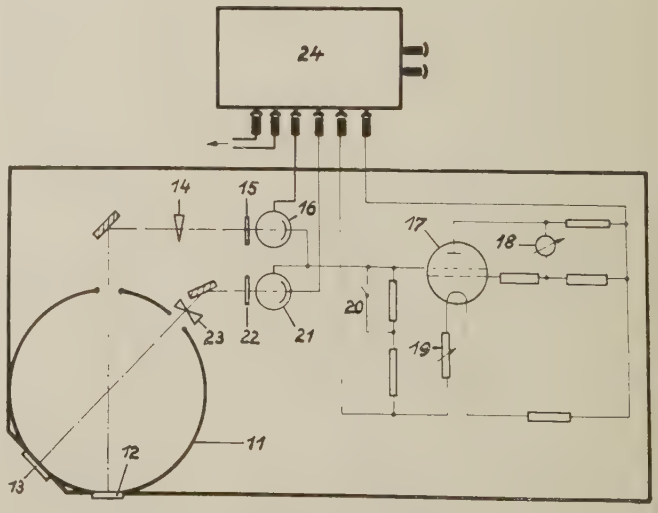

Fig. 2. A schematic diagram showing the geometry and circuitry of the Elrepho

11—Ulbricht sphere; 12—specimen; 13—comparison reflector; 14—gray wedge; 15 and 22—filters; 16 and 21—phototubes; 17—amplifier tube; 18—null indicator; 19—zero point adjuster; 20—sensitivity key; 23—photometer diaphragm; 24—power supply unit.

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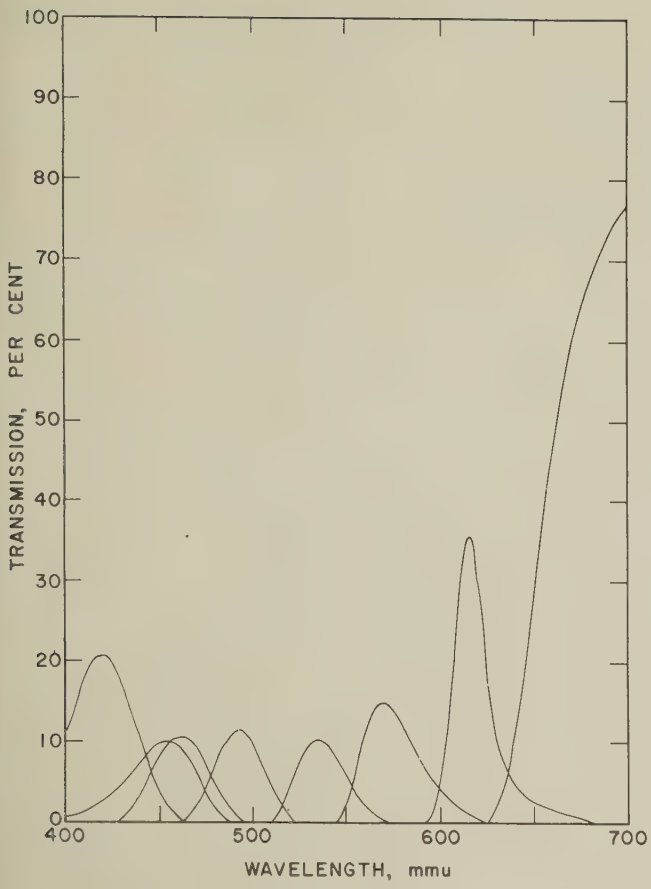

Fig. 3. Spectral transmission curves for the eight filters in the Elrepho

(*1–12*). The instrument employs sphere geometry and is equipped with eight narrow-band filters (including one filter designed specifically for measuring brightness) which permit measuring reflectance at eight points across the visible spectrum. The specimen and comparison reflector are diffusely illuminated in an Ulbricht sphere (in which the light sources are two incandescent lamps) and only the light reflected perpendicularly from both the specimen and standard is measured. The manufacturer is aware that reflectance readings obtained using the instrument do not agree numerically with standard brightness (*13*). However, reflectance data obtained with the "Specific Calibration Procedure" would be in conformity with the standard brightness scale.

DESCRIPTION OF THE INSTRUMENT

The Zeiss "Elrepho," shown in Fig. 1, consists of two parts. The main part contains the Ulbricht sphere, the light sources, the null indicator, the photometer diaphragm, phototubes, and other components of the optical system. The other part contains the power supply, which is connected to the instrument with a cable. The instrument is designed to operate with a 220-v., 50-cycle power source. The manufacturer furnishes a transformer which permits operation with a 115-v., 60-cycle source. A schematic diagram showing the geometry and circuitry employed is reproduced in Fig. 2.

The specimen aperture (35-mm. diam.) is located at the bottom of the sphere and the specimen or standard is held in place by means of a spring-loaded specimen holder. Large sheets can be measured conveniently with this arrangement. A second aperture, located above the measuring aperture and toward the front of the sphere, is covered by the white surface of the comparison reflector (*not* the standard). Located on the right side of the instrument are the measuring drum from which the reflectance of the specimen can be read directly, and a milled knob controlling a gray wedge which permits balancing the light reflected from the standard and the comparison reflector. This balance is shown by the null-indicating meter located at the front of the instrument. The instrument is direct reading so that after standardizing it is not necessary to refer to the standard to evaluate subsequent specimens. The stability of the instrument determines the length of time one may continue evaluating specimens without further reference to the standard. A window through which the specimen may be viewed is also located on the instrument front. Eight narrow-band filters, set in a rotatable disk, permit the measurement of reflectance at eight points across the visible spectrum. The transmission curves for these filters are shown in Fig. 3. The lower portion of the sphere is provided with a water-cooled jacket to prevent excessive heating of the instrument. A cartridge filled with a drying agent (silica gel) is installed in the main part of the instrument to minimize electrical difficulties that might arise from excessive moisture.

Two incandescent lamps (12 v., 40 w.) mounted within the sphere 180° apart serve as light sources. Two small, white baffles properly located within the sphere allow only light diffusely reflected from the sphere wall to strike both the specimen and comparison reflector. With reference to Fig. 2, the light reflected from the specimen or standard traverses a gray wedge, 14, the filter, 15, and falls on phototube 16; the light reflected from the comparison reflector strikes the measuring phototube, 21, after passing through the photometer diaphragm, 23, and a filter, 22, which is identical to filter 15. The two phototubes are connected in series and only the differential current is amplified and indicated on the null-indicating meter. The sensitivity of the circuit can be increased by a factor of approximately 50 by depressing the sensitivity key, 20, located on the left side of the instrument. Opening this key adds resistance to the grid circuit. The electrical balancing is performed with the null point regulator knob located on the left side of the instrument.

STUDY OF INSTRUMENTAL VARIABLES

Effects of Changes in Line Voltage and Line Frequency

The Elrepho is connected to the power line through a transformer (furnished by the manufacturer) as the instrument was designed for use with a 220-v., 50-cycle source. The manufacturer states that line voltage variations of the order of ±10% of normal line voltage would in no way affect the accuracy or use of the instrument.

A variable frequency alternator was employed for both the voltage and frequency study. With the line voltage held constant at 115 v., the measuring drum was set to the nominal value of the standard and the null indicator was set at zero by adjusting the gray wedge. The line frequency was varied in one-cycle

steps from 58 to 62 cycles per sec. The voltage was varied from 105 to 125 v. for each frequency. A reflectance reading was obtained for each frequency and voltage without changing the setting on the gray wedge.

The instrumental reading is independent of frequency variations from 58 to 62 cycles per sec. and line voltage variations from 105 to 125 v.; compensation for frequency and voltage fluctuations is nearly perfect.

Linearity of Response

The Elrepho is designed with a compensator on the photometer diaphragm, thereby making it possible through paper adjustment of the compensator to correct for deviation from linearity of the photometric system. The manufacturer furnishes on request a gray standard (having an assigned value of approximately 50%), for making the compensator adjustment. The linearity of response of the Elrepho was determined without adjusting the compensator.

A zero external resistance circuit employing a blocking layer photocell, balancing potential, and a sensitive galvanometer was used to check the linearity of response. This system is known to be linear from past studies.

Six neutral wire screens having different transmissions were placed, one at a time, in front of the filter, 15, to attenuate the light beam of the Elrepho. The transmission of each screen was measured, first with the zero external resistance circuit and then with the Elrepho. The position of the screen was not changed between the measurements so that the nonuniformity of the screen transmission did not influence the result. A front-surfaced mirror placed in front of phototube, 16, deflected the light beam from the phototube to the photocell in the zero external resistance circuit. The front-surfaced mirror was removed when the measurement was made with the Elrepho. The excellent stability characteristics of the Elrepho were a great help in performing these measurements accurately.

The points on the reflectance scale which were checked were 17, 30, 48, 60, 73, and 89. The zero setting was proper and the 100 point is right by definition. The error in the linearity of response of the Elrepho was not over 0.1% of full scale and may be less than this figure as the inaccuracy of the method of determining the linearity of response is of the order of 0.1%.

Effects of Instrumental Drift and Changes in Ambient Temperature

There is no recommended warm-up period for the Elrepho. As soon as the instrument has been electrically and optically balanced it is ready for use. The manufacturer does recommend that the operator check the standard at 5-min. intervals and check the electrical zeroing at 5 to 20-min. intervals.

The drift characteristics were studied starting immediately after the instrument had been electrically and optically balanced and continued over a 24-hr. period. This study was performed at a constant room temperature of 75°F. Without further adjustment of the instrument settings, the measuring drum readings (obtained by zeroing the null indicator) were recorded at varying intervals over the 24-hr. period. The data are plotted in Fig. 4.

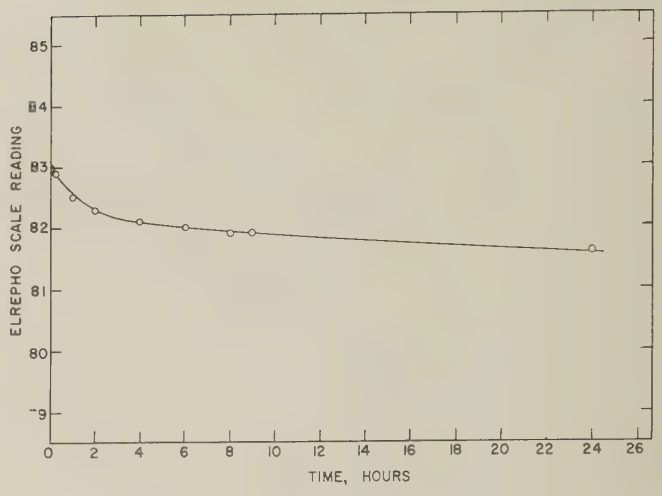

Fig. 4. Dependence of Elrepho scale reading on instrumental drift

The drift was small over the 24-hr. period and if one followed the manufacturer's recommendation of checking the standard at 5-min. intervals and the electrical balance at 5 to 20-min. intervals, the observed drift would not impair the accuracy of the reflectance measurements.

To determine the effects of changes in ambient temperature on the Elrepho reflectance reading, the room temperature was raised rapidly from 75 to 97°F. After allowing the instrument to reach equilibrium at the higher room temperature, the room was cooled rapidly to the original temperature. Prior to beginning the study, the instrument was in continuous operation for a 24-hr. period and was electrically and optically balanced. Reflectance readings were obtained at varying intervals through the period of temperature change. The results of this study are given in Table I, where it will be seen that instrumental error associated with changing temperature is negligible.

Effects of High Relative Humidity

Although the manufacturer has installed a drying cartridge in the instrument to maintain a low moisture condition, it seemed desirable, because of the high value of the grid leak resistance, to observe the performance of the instrument under extreme conditions of humidity.

Table I. Effects of Changes in Ambient Temperature on Elrepho Reading

Time, hr.	*Temperature, °F.*	*Elrepho reflectance, %*	*Difference*
	81	80.8	
0.08	89	80.8	0.0
0.25	91	80.8	0.0
0.42	93	80.8	0.0
0.58	94	80.8	0.0
0.92	96	80.9	+0.1
1.08	97	80.9	+0.1
1.50	98	80.9	+0.1
1.75	99	80.9	+0.1
2.08	99	80.9	+0.1
2.58	100	80.9	+0.1
3.25	100	80.9	+0.1
3.42	95	80.9	+0.1
3.50	81	81.0	+0.2
4.50	75	80.9	+0.1

Note: Instrument was in continuous operation approximately 24 hr. prior to obtaining the above data.

Table II. Effects of High Relative Humidities on Elrepho Reading

Time, hr.	*Elrepho reflectance, %*	*Difference*
..	81.0	
0.08	80.5	−0.5
0.17	80.3	−0.7
0.25	80.7	−0.3
0.42	81.2	+0.2
0.67	80.6	−0.4
0.83	80.7	−0.3
1.00	80.8	−0.2
1.33	81.1	+0.1
1.58	81.3	+0.3
1.83	81.2	+0.2
2.17	81.3	+0.3
3.42	81.5	+0.5
3.92	81.5	+0.5

Note: The room conditions during the study were: temperature, 93°F.; R. H., 90%.

For this study, the instrument was moved as rapidly as possible (to avoid moisture condensation on optical components) from a room temperature of 95°F. and relative humidity of approximately 25% into a room where the temperature was 93°F. and the relative humidity 90%. An enameled steel plaque was placed over the specimen opening and a null balance was obtained with the reflectance scale dial set to the value of the plaque. The null balance was maintained throughout the test by adjusting the reflectance scale dial at frequent intervals. The data are presented in Table II.

The changes noted show the effects of high relative humidity on the electronic system of the Elrepho when the readings are taken directly without employing a reference standard. If a reference standard were employed at frequent intervals, as recommended by the manufacturer, then the effects would be negligible.

Spectral Response

The overall spectral response for the Elrepho "as-received" was determined by obtaining the product of the spectral response of the phototube (S-4 response), the transmission curve for the blue filter (brightness filter), the spectral characteristics of the infrared absorbing filter, and the spectral energy distribution of the illuminant (spectral characteristics of the sphere wall included). The spectral response data for the phototube, the spectral characteristics of the infrared absorbing filter and the spectral energy distribution of the illuminant were furnished by the manufacturer. The relative spectral response curve for both the Elrepho and the standard brightness tester are shown in Fig. 5. The transmission curve for the Elrepho brightness filter is shown in Fig. 6. Curves showing the spectral energy distribution of the illuminant for both the Elrepho and the standard brightness tester are shown in Fig. 7.

The effective wavelength of the Elrepho "as-received" was determined through the use of two glass filters, one having a transmission curve of "linear" positive slope and the other having a transmission curve of "linear" negative slope (*14*). If an instrument is photometrically accurate, the effective wavelengths as determined with the two filters should be in agreement. The measured effective wavelengths as determined with the filters having transmission curves of positive and negative slopes were, respectively, 454.7 and 455.1 mμ, the average of which is 454.9 μ.

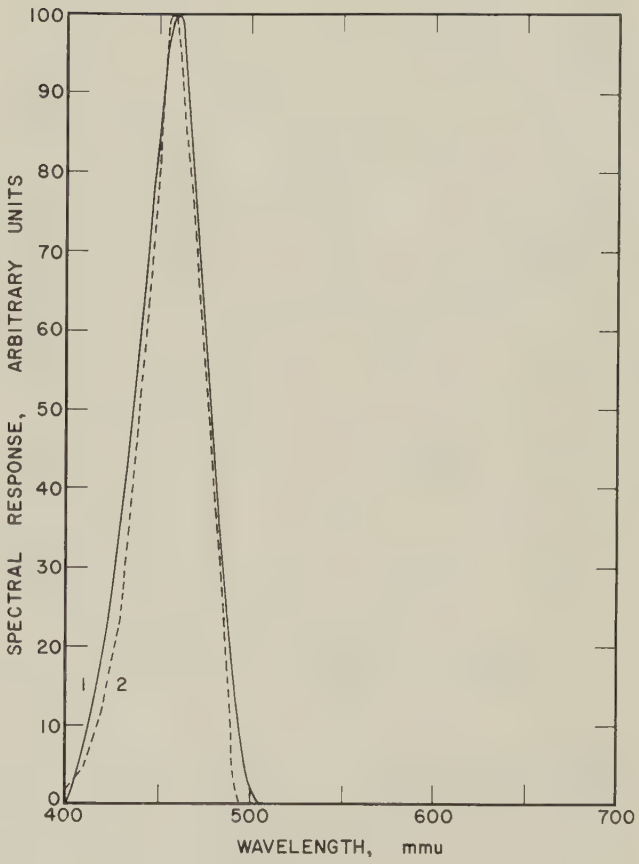

Fig. 5. Relative spectral response

1—I.P.C. standard brightness tester; 2—Elrepho.

Sphere Geometry

True sphere geometry is ideal for the measurement of reflectance as the surface qualities of the specimen have very little influence on the measurement. Moreover, sphere geometry permits accurate application of theories of light scattering and absorption, such as the Kubelka-Munk theory. It is essential, however, from the viewpoint of a standard brightness scale, that any geometry must be closely controlled for all the instruments based on the standard scale. The goniophotometric surfaces for paper vary appreciably; thus, any deviations in geometry from the standard will cause differences in the measurement of reflectance (brightness). It is impossible to evaluate the effects of variables of sphere geometry on the basis of an investigation of a single instrument as it is a problem of how closely the variables are controlled between a number of instruments rather than the deviation of a single instrument from true sphere geometry. A further discussion of sphere geometry is given later in this report.

Comparison of Elrepho Reflectance Values with Standard Brightness

Two unevaluated white standards (matte surface) were furnished with the instrument. The manufacturer recommends that these standards be calibrated by means of freshly smoked magnesium oxide surfaces, using the Elrepho.

Reflectance values (based on the white standard which was calibrated in terms of magnesium oxide)

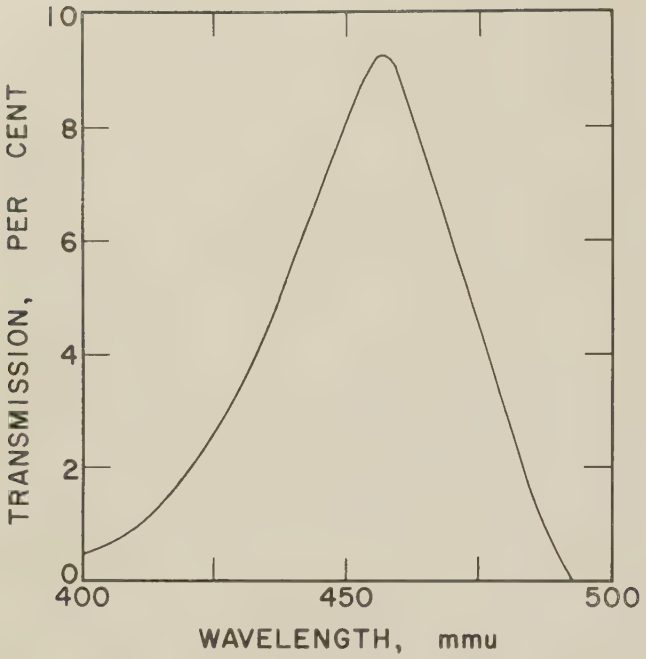

Fig. 6. Spectral transmission curve for the Elrepho brightness filter

were obtained for a series of papers and fillers that are described in Table III. Spectral reflectivity curves for the papers and fillers (not including the papers with fluorescent materials added) were obtained using the General Electric Recording Spectrophotometer (GERS) and are shown in Figs. 8 through 12. The standard method was employed for preparation of the filler

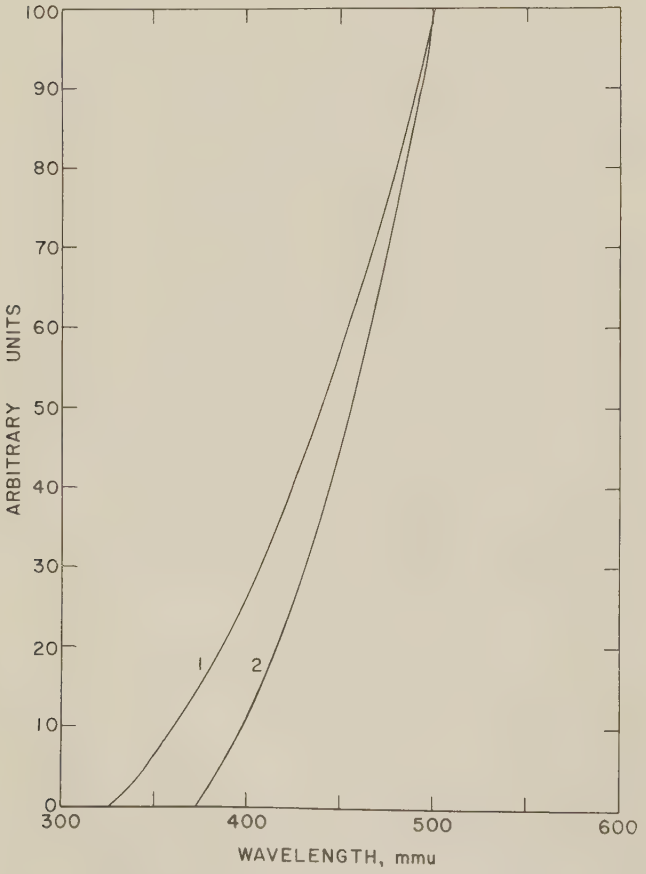

Fig. 7. Spectral energy distribution of the light incident on the specimen

1—I.P.C. standard brightness tester; 2—Elrepho.

Table III. Description of Samples Used in Comparison of Elrepho Reflectance with Standard Brightness

Sample no.	*Description*	*Standard brightness, %*
1	Unbleached hardwood kraft handsheet	41.7
2	Bleached hardwood kraft handsheet	74.8
3	Unbleached softwood sulphite handsheet	58.1
4	Bleached softwood sulphite handsheet	87.4
5	Unbleached softwood kraft handsheet	21.0
6	Bleached softwood kraft handsheet	81.9
7	Bleached softwood soda handsheet	74.3
8	Bleached hardwood sulphite handsheet	82.7
9	Uncrêped facial tissue	78.7
10	Commercial unbleached kraft	23.5
11	Commercial groundwood	48.0
12	Bleached Manila liner stock	55.8
13	White patent coated board	78.0
14	Uncoated book paper	70.4
15	Machine-coated book paper	79.6
16	Titanium-filled paper (3.56% filler)	85.4
17	Wrapping tissue paper	73.5
18	Crêped facial tissue	74.9
19	24-lb. unwaxed bread wrap	75.8
20	24-lb. waxed bread wrap	64.4
21	Newsprint paper	60.9
22	Commercial bond	80.6
23	Commercial bond with a fluorescent whitening agent added	93.0
24	Ledger paper	76.5
25	Cast-coated paper	89.7
26	Titanium oxide	95.3
27	Pure calcium carbonate	98.6
28	Whatman No. 1 filter paper	89.7
29	Whatman No. 1 filter paper containing a fluorescent dye	98.1
30	Commercial clay	78.2

samples as the compacting device supplied with the Elrepho does not necessarily apply the proper pressure. The data obtained are presented in Table IV. The large differences observed between Elrepho reflectance values and standard brightness for the nonfluorescent papers can be attributed to the geometric and spectral differences between the two instruments and the difference in standards. The reflectance of magnesium oxide

Table IV. Comparison with Standard Brightness of the Elrepho Reflectance Determined in Accordance with the Manufacturer's Calibration Procedure

Sample no.	*Standard brightness, %*	*Elrepho reflectance, %*	*Difference*
1	41.7	42.4	+0.7
2	74.8	75.5	+0.7
3	58.1	58.9	+0.8
4	87.4	88.8	+1.4
5	21.0	21.5	+0.5
6	81.9	83.5	+1.6
7	74.3	74.9	+0.6
8	82.7	83.8	+1.1
9	78.7	81.5	+2.8
10	23.5	25.0	+1.5
11	48.0	49.0	+1.0
12	55.8	58.1	+2.3
13	78.0	78.4	+0.4
14	70.4	71.2	+0.8
15	79.6	79.9	+0.3
16	85.4	86.6	+1.2
17	73.5	75.2	+1.7
18	74.9	75.3	+0.4
19	75.8	76.4	+0.6
20	64.4	66.7	+2.3
21	60.9	62.2	+1.3
22	80.6	81.6	+1.0
23	93.0	92.3	−0.7
24	76.5	77.5	+1.0
25	89.7	88.9	−0.8
26	95.3	96.8	+1.5
27	98.6	99.1	+0.5
28	89.7	91.1	+1.4
29	98.1	95.8	−2.3
30	78.2	78.2	0.0

Note: Effective wavelength of Elrepho, as-received, was 454.9 μ.

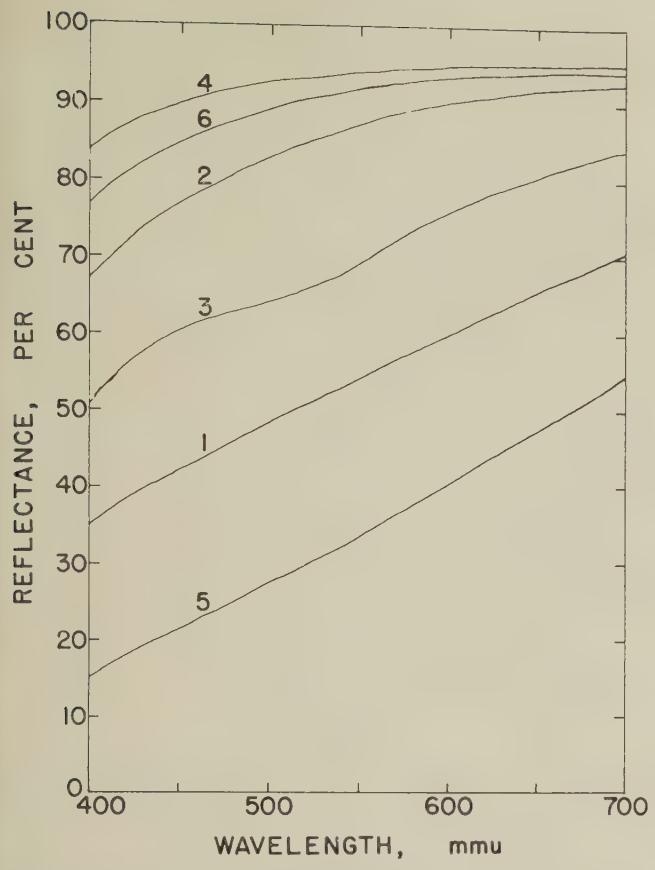

Fig. 8. Spectral reflectivity curves for papers described in Table III

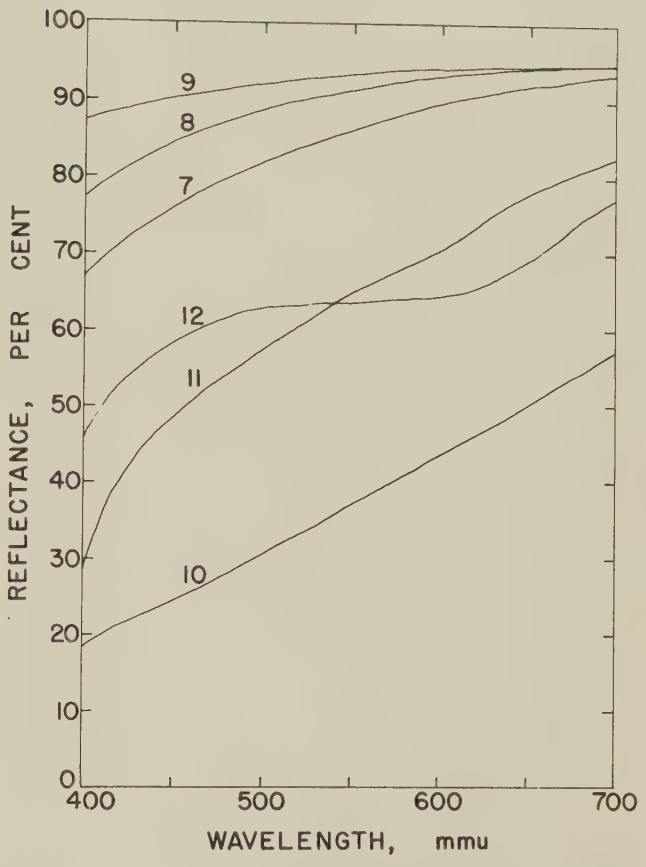

Fig. 9. Spectral reflectivity curves for papers described in Table III

can vary appreciably, depending upon the circumstances of preparation. The low Elrepho reflectance values for the papers containing a fluorescent material are due to the difference in the spectral characteristics of the light incident on the specimen as shown in Fig. 7.

A two-component glass filter having transmission characteristics similar to the filter in the standard brightness tester was installed in the Elrepho, yielding an effective wavelength for the instrument of 457.2 mμ, which is essentially the value for standard brightness. The same series of papers were again evaluated on both the standard brightness tester and the Elrepho, resulting in the data presented in Table V. With the exception of the papers containing the fluorescent materials, the observed differences between the reflectance values obtained with the Elrepho and the standard brightness tester can now be attributed to geometric and standard differences.

A third set of data, shown in Table VI, were obtained, using as a standard on the Elrepho an opaque pad of bond paper having an assigned value based on the standard brightness scale. These differences show the effects of the different geometries in the two instruments. The differences are still too great to permit the measurement of brightness of papers in general with the Elrepho employing a single standard based on the standard brightness scale.

A fourth set of data were obtained for several of the nonfluorescent papers employing the "Specific Calibration Procedure" (*10*). Standardization in this manner accounts for variations in the spectral, photometric and geometric characteristics between the instruments and permits the accurate measurement of brightness based on the standard brightness scale, when using a nonstandard instrument. The data given in Table VII show good agreement between the reflectance values obtained with the Elrepho and the standard brightness tester.

Factors Influencing Reflectances Measured with an Instrument Employing Sphere Geometry

The study thus far presents a comparison of reflectance data obtained with two instruments having different geometries. To understand better the effects of sphere geometry on the reflectance measurement, a comparison was made between reflectance data obtained with the General Electric Recording Spectrophotometer (GERS) and the Elrepho. An instrument employing true sphere geometry would be ideal for this comparison but this would be impractical. The variables which cause the GERS to differ from true sphere geometry have been studied in the past and the influence of each variable has been determined. A special technique has been developed which permits the measurement of the absolute reflectance of the sphere lining; thus, a uniform and high reflectance of the inner surface of the sphere on the GERS can be maintained.

The goniophotometric surfaces for papers and fillers vary from almost a true sphere for a good diffuser (Lambertian diffuser) to a pronounced ellipsoid with or without a bulge or pip where the angle of reflection equals the angle of incidence. In the case of the perfect diffuser, the particular geometry employed is not critical. Any deviation from a perfect diffuser makes it essential that the geometry be accurately known and controlled in order to obtain a significant reflectance measurement. Normally, when speaking of sphere geometry, we refer to a modified version wherein the

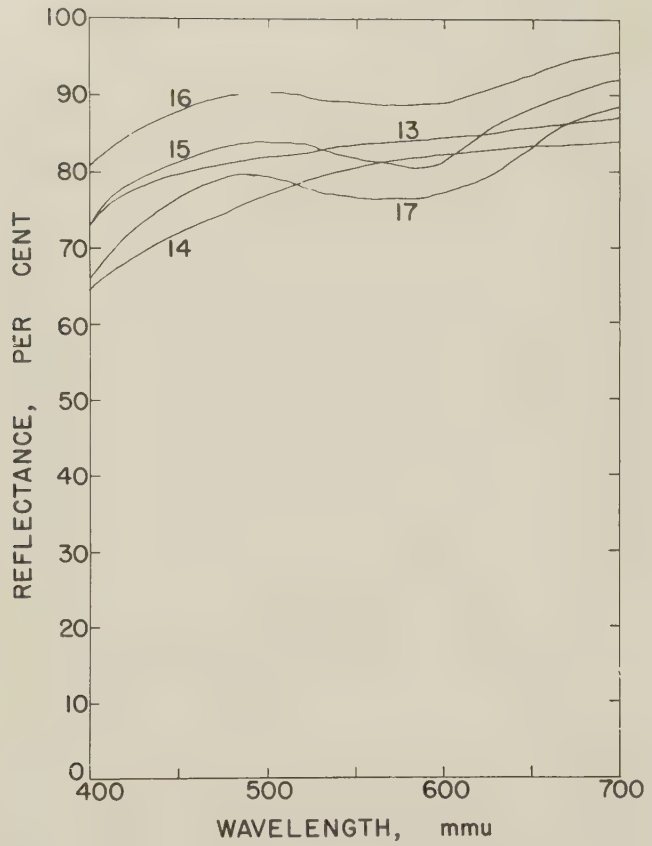

Fig. 10. Spectral reflectivity curves for papers described in Table III

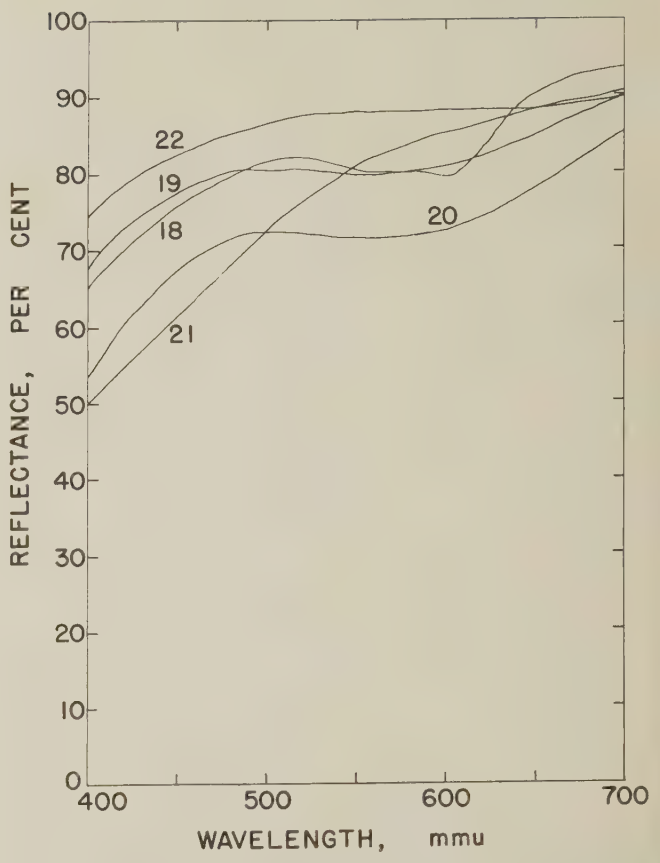

Fig. 11. Spectral reflectivity curves for papers described in Table III

openings in the sphere, the reflectance of the sphere lining, the area of the specimen illuminated relative to the area viewed and the means of illuminating and viewing are all variables which influence the result. The characteristics of the sphere lining are probably the most difficult to control. Under ideal conditions of operation, when the original application of the sphere lining results in a uniform and high reflectance coating, when the sphere is maintained in a clean atmosphere,

Table V. Comparison with Standard Brightness of the Elrepho Reflectance Determined After Adjusting the Spectral Response to Agree with That of the Standard Brightness Tester

Sample no.	*Standard brightness, %*	*Elrepho reflectance, %*[a]	*Difference*
1	41.7	43.0	+2.3
2	74.8	76.0	+1.2
3	58.1	59.4	+1.3
4	87.4	88.9	+1.5
5	21.0	22.0	+1.0
6	81.9	83.8	+1.9
7	74.3	75.4	+1.1
8	82.7	84.1	+1.4
9	78.7	81.8	+3.1
10	23.5	25.5	+2.0
11	48.0	49.8	+1.8
12	55.8	58.5	+2.7
13	78.0	78.7	+0.7
14	70.4	71.6	+1.2
15	79.6	80.2	+0.6
16	85.4	86.7	+1.3
17	73.5	75.5	+2.0
18	74.9	75.7	+0.8
19	75.8	76.9	+1.1
20	64.4	67.2	+2.8
21	60.9	63.0	+2.1
22	80.6	81.8	+1.2
23	93.0	92.1	−0.9
24	76.5	77.7	+1.2
25	89.7	88.9	−0.8
26	95.3	96.8	+1.5
27	98.6	99.0	+0.4
28	89.7	91.1	+1.4
29	98.1	95.5	−2.6
30	78.2	78.4	+0.2

[a] The spectral characteristics of the Elrepho matched those of the standard brightness tester in the visible region of the spectrum when obtaining the above data.

Table VI. Comparison with Standard Brightness of Elrepho Reflectance, Using a Standard Evaluated with the I.P.C. Master Brightness Tester

Sample no.	*Standard brightness, %*	*Elrepho reflectance, %*[a]	*Difference*
1	41.5	42.3	+0.8
2	74.7	74.7	0.0
3	58.2	58.4	+0.2
4	87.2	87.4	+0.2
5	21.1	21.7	+0.6
6	81.7	82.3	+0.6
7	74.4	74.2	−0.2
8	82.7	82.7	0.0
9	78.5	80.4	+1.9
10	23.6	25.1	+1.5
11	48.0	49.0	+1.0
12	55.8	57.6	+1.8
13	78.0	77.3	−0.7
14	70.4	70.4	0.0
15	79.4	78.8	−0.6
16	85.2	85.2	0.0
17	73.4	74.2	+0.8
18	75.0	74.6	−0.4
19	75.8	75.5	−0.3
20	64.6	66.0	+1.4
21	61.1	61.9	+0.8
22	80.6	80.4	−0.2
23	92.8	90.6	−2.2
24	76.6	76.4	−0.2
25	89.4	87.4	−2.0
28	89.4	89.5	+0.1
29	98.7	93.9	−4.8

[a] The spectral characteristics of the Elrepho matched those of the standard brightness tester in the visible region of the spectrum when obtaining the above data.

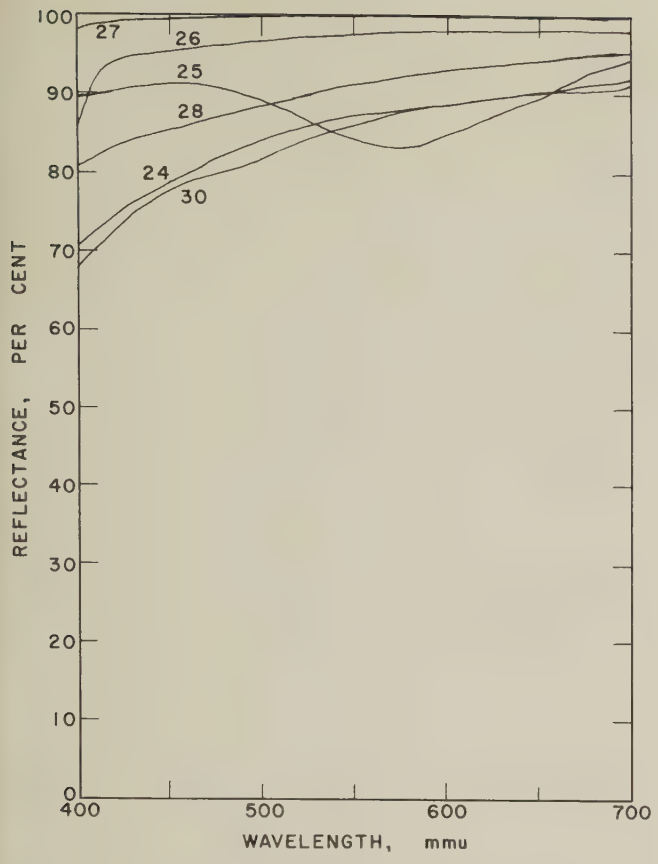

Fig. 12. Spectral reflectivity curves for papers described in Table III

and when the lining is not exposed for long periods to intense radiation or does not change its spectral characteristics for other reasons, then an instrument employing sphere geometry would give consistent results. Typical paper mill operations make it rather difficult to meet the requirement of atmospheric cleanliness. The water-cooled jacket around a portion of the sphere on the Elrepho improves the spectral stability of the lining by maintaining the sphere wall at a relatively low temperature. Locating the specimen aperture at the bottom of the sphere on the Elrepho rather than on the top or side helps to keep the sphere clean.

Table VII. Comparison with Standard Brightness of Elrepho Reflectance, Determined in Accordance with the Specific Calibration Procedure

Sample no.	*Standard brightness, %*	*Elrepho reflectance, %*	*Difference*
3	58.1	58.1	0.0
10	23.6	23.6	0.0
22	80.5	80.5	0.0
25	89.5	89.4	−0.1

Reflectance data on the samples described in Table III were obtained with the Elrepho and the GERS; these data are given in Table VIII. The two instruments were standardized with the same block of magnesium carbonate. The wavelength cam on the GERS was set to the same value as the Elrepho effective wavelength. The first column in Table VIII gives the sample number; the second column gives the reflectances obtained with the Elrepho; the third column gives the reflectances obtained with the GERS; the fourth column gives the difference in reflectance between the two instruments. These readings were taken directly from the instruments. The fifth column gives the adjustment in the reflectance values obtained on the Elrepho because of the difference in the spectral band widths employed in the GERS and the Elrepho. The sixth column gives the adjusted Elrepho reflectance values. The seventh column repeats the GERS reflectance values given in column three. In view of the fact that both instruments are photometrically accurate, the remaining discrepancies (after correcting the Elrepho readings for the appreciable spectral band width employed in that instrument) are believed to be attributable to differences in geometry of the two instruments.

Table VIII. Comparison of Reflectance Data Obtained with the Elrepho and GERS

Sample no.	*Reflectance, %*		*Difference, %*	*Adjustment in Elrepho reflectance values*[c]	*Reflectance, %*		*Difference, %*
	Elrepho[a]	*GERS*[b]			*Elrepho*[d]	*GERS*	
1	43.02	43.18	−0.16	0.1	43.12	43.18	−0.06
2	76.00	76.96	−0.96	0.3	76.30	76.96	−0.66
3	59.38	59.40	−0.02	...	59.38	59.40	−0.02
4	88.94	89.64	−0.70	0.2	89.14	89.64	−0.50
5	22.02	22.56	−0.54	0.1	22.12	22.56	−0.44
6	83.76	84.72	−0.96	0.3	84.06	84.72	−0.66
7	75.44	76.50	−1.06	0.5	75.94	76.50	−0.56
8	84.06	84.86	−0.80	0.2	84.26	84.86	−0.60
9	81.82	82.64	−0.82	0.1	81.92	82.64	−0.72
10	25.48	25.70	−0.22	...	25.48	25.70	−0.22
11	49.84	49.82	+0.02	0.5	50.34	49.82	+0.52
12	58.52	58.68	−0.16	0.5	59.02	58.68	+0.34
13	78.68	79.02	−0.34	0.2	78.88	79.02	−0.14
14	71.56	71.86	−0.30	0.1	71.66	71.86	−0.20
15	80.16	80.78	−0.62	0.3	80.46	80.78	−0.32
16	86.68	87.64	−0.96	0.3	86.98	87.64	−0.66
17	75.54	76.36	−0.82	0.4	75.94	76.36	−0.42
18	75.68	76.56	−0.88	0.5	76.18	76.56	−0.38
19	76.86	77.42	−0.56	0.4	77.26	77.42	−0.16
20	67.18	67.84	−0.66	0.5	67.68	67.84	−0.16
21	63.00	62.78	+0.22	...	63.00	62.78	+0.22
22	81.80	82.70	−0.90	0.3	82.10	82.70	−0.60
24	77.74	78.34	−0.60	0.2	77.94	78.34	−0.40
25	88.94	89.56	−0.62	0.3	89.24	89.56	−0.32
28	91.10	91.40	−0.30	...	91.10	91.40	−0.30

a The measured effective wavelength of the Elrepho was 457 mμ using a special filter (Corning doublet).
b The GERS reflectance values were obtained at 457 mμ.
c See text.
d See text (Elrepho reflectance values with adjustment added).

The differences in column eight are too large to be accounted for on the basis of differences in the GERS sphere from true sphere geometry. The absolute reflectance of the wall of the GERS sphere at the Institute is maintained above 0.955 at all times, and this renders negligible the effect of first-reflected light and other deviations from true sphere geometry.

The variation in radiant energy from the Elrepho sphere wall was checked visually and experimentally. The check was made instrumentally by inserting a rod of slightly larger diameter than the viewed area into the specimen aperture. The end of the rod was beveled so that when a front-surfaced reflector was placed on the beveled end, the light reflected from the sphere wall on a line with the lamps was directed to the measuring phototube. The rod was made short enough so that it could not interfere with the reference beam. In the first case, the rod was coated entirely with magnesium oxide and was inserted into the specimen aperture. A shoulder which fitted the specimen aperture was machined on the rod to guide it while it was being rotated. The instrument was balanced at "90%" and the rod was rotated in steps through 360°. The changes in reading were noted. With the rod coated with magnesium oxide, the changes in reading throughout the rotation were several per cent, indicating that there was very little disturbance to the reference beam and that if a large enough area of the sphere was furnishing the light to the diffuse reflector on the rod, the radiant energy appeared to be fairly uniform. The next test was to remove the magnesium oxide from the beveled surface and replace it with a front-surfaced mirror. The azimuthal variation was now quite pronounced, indicating that the radiant energy reflected from the sphere wall lining was not uniform throughout the sphere. This was related to the position of the two sources. The visual inspection further substantiated the fact that the sphere was not uniformly illuminated.

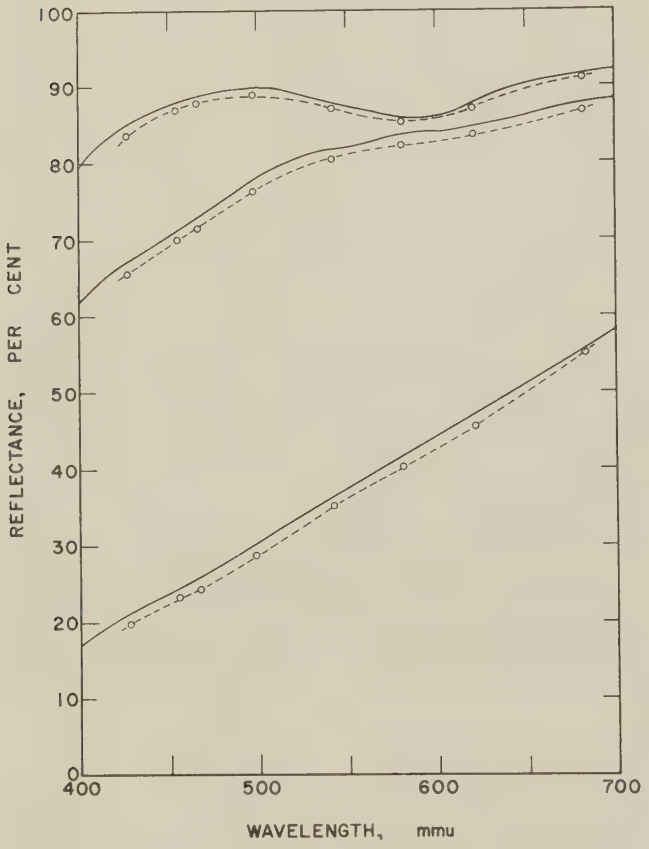

Fig. 13. Spectral reflectivity curves for three papers obtained using the Elrepho and the GERS

——— GERS; – – – – Elrepho.

As the discrepancies shown in the last column of Table VIII are small, it is difficult to establish with certainty that they are attributable to differences between the sphere geometries of the two instruments. The work with both instruments was done with such precision and accuracy as to warrant an association of the discrepancies beyond 0.3% with differences in geometry. Moreover, the algebraic sign of the differences is consistent with the nature of the deviation of the goniophotometric surfaces for papers from that of a perfect diffuser, and with the small deviations of geometry of the Elrepho from the true sphere geometry.

COLOR CONTROL WITH THE ELREPHO

Spectral reflectivity curves were obtained for three paper samples on the GERS and the Elrepho to demonstrate the fact that the Elrepho can be used to control color. These curves, presented in Fig. 13, show that the Elrepho can be used effectively for color control, particularly for "white" or lightly tinted papers; it should be noted that the points plotted in Fig. 13 are not at the wavelengths quoted by the manufacturer but, rather, at "effective wavelengths" determined in the present study (the differences between the quoted and the effective wavelengths for some of the filters were several millimicrons). Papers having complex spectral reflectivity curves would not be evaluated accurately on the Elrepho because of the spectral band width employed. This condition is typical for instruments employing filters for defining the spectral band width. Essentially monochromatic light should be used to measure color accurately when the spectral reflectivity curve is complex.

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UNITED STATES PATENTS ON PAPERMAKING

Third Quarter, 1959 — *Compiled by The Institute of Paper Chemistry*

THE following list of United States patents has been compiled from the current numbers of the Official Gazette of the United States Patent Office. Because, as a rule, only one claim is published in the gazette, it is not claimed that the list is complete; also, it is possible that the list may contain some patents that do not apply specifically to pulp and paper manufacture. Copies of any of the following patents may be obtained from the United States Patent Office, Washington 25, D. C., by sending twenty-five cents for each patent desired. Or, those desiring the patents on *microcards* should write to The Institute of Paper Chemistry, Appleton, Wis.

July 7, 1959

Bates, Charles K. Radio tube carton. U. S. patent 2,893,623. Filed July 2, 1958. 3 claims. Assigned to Sylvania Elec. Products Inc. [Cl. 229-39.] Internal guide and supporting members are provided.

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Harnish, Don P., and Brukardt, Robert W. Nestable berry tray. U. S. patent 2,893,621. Filed May 25, 1955. 6 claims. Assigned to Crown Zellerbach Corp. [Cl. 229-34.]

Harvey, Edmund N., Jr. Copying paper and method of manufacture. U. S. patent 2,893,890. Filed Oct. 25, 1957. 2 claims. Assigned to Kee Lox Mfg. Co. [Cl. 117-36.]

Hawkinson, Alfred T. Bleaching a paper web with peroxide. U. S. patent 2,893,819. Filed Aug. 8, 1955. 2 claims. Assigned to E. I. du Pont de Nemours and Co. [Cl. 8-111.]

Hill, Frank R. Individual condiment containers. U. S. patent 2,893,618. Filed May 27, 1957. 1 claim. [Cl. 229-17.] A salt or pepper container is formed of paperboard to have frustopyramidal shape, a handle, and tear-tab opening means.

Hutton, Frank E. Process and apparatus for the recovery of heat and chemicals from pulp liquor. U. S. patent 2,893,829. Filed May 19, 1953. 6 claims. Assigned to Babcock & Wilcox Co. [Cl. 23-48.]

Jensen, Stephen F. Carrying handle with locking feature. U. S. patent 2,893,549. Filed May 9, 1955. 2 claims. Assigned to American Can Co. [Cl. 206-65.] Two milk cartons banded together with a paper band and the assembly is provided with a paperboard handle.

Johnson, Eugene C. Stakes for log bunks. U. S. patent 2,893,330. Filed July 25, 1956. 2 claims. [Cl. 105-382.]

Jones, Rexford W. Printing of corrugated board. U. S. patent 2,893,320. Filed March 29, 1956. 8 claims. Assigned to Fort Wayne Corrugated Paper Co. [Cl. 101-426.] An improved offset blanket permits printing of corrugated board by a dry relief offset process.

Justus, Edgar J., and Daane, Robert A. Paper machine dryer condensate control. U. S. patent 2,893,136. Filed July 5, 1957. 6 claims. Assigned to Beloit Iron Works. [Cl. 34-119.]

Kunz, Hugo A. Paper roll holder and cutter with printing attachment. U. S. patent 2,893,316. Filed Jan. 17, 1958. 7 claims. [Cl. 101-226.] An apparatus for supporting and dispensing a roll of wrapping paper is provided with means to imprint the paper as it is dispensed.

Lancaster, Arthur W. Cutting and gluing means for paper strip. U. S. patent 2,893,191. Filed Aug. 27, 1956. 15 claims. Assigned to Williams & Wilson Ltd. [Cl. 53-380.] These devices are for a machine which applies a paper wrapper to a paper roll.

Lancaster, Arthur W. Roll wrapping. U. S. patent 2,893,190. Filed July 6, 1955. 5 claims. Assigned to Williams & Wilson Ltd. [Cl. 53-380.] A machine for wrapping a paper roll in a paper wrapper is provided with means to crimp the ends of the wrapper about the roll.

Lancaster, Arthur W. Wrapping paper supply means. U. S. patent 2,893,189. Filed Feb. 8, 1956. 3 claims. Assigned to Williams & Wilson Ltd. [Cl. 53-198.] Wrapping paper supply means are provided in a machine for wrapping paper rolls.

Lienart, Marcel. Apparatus for closing open mouth bags or the like. U. S. patent 2,893,184. Filed Feb. 18, 1957. 15 claims. Assigned to St. Regis Paper Co. [Cl. 53-75.]

Light, George S. Price indicating tickets. U. S. patent 2,893,145. Filed Sept. 19, 1957. 5 claims. [Cl. 40-25.] A tamperproof garment price tag is provided.

Litty, John R. Frankfurter packaging machine. U. S. patent 2,893,186. Filed June 15, 1954. 4 claims. [Cl. 53-124.] A group of frankfurters are compressed and inserted into a bag.

Magill, Donald G. Method of preparing a container for shipment and subsequent use. U. S. patent 2,893,295. Filed Oct. 24, 1955. 1 claim. Assigned to American Can Co. [Cl. 93-36.] A flat-top paper milk carton is constructed so that it may be collapsed to flat form for shipment.

Mann, Walter J. Horizontal corrugated paper tube and method of making the same. U. S. patent 2,893,436. Filed Oct. 12, 1954. 8 claims. Assigned one third to Ephraim H. Roden, and one third to George C. Ickes, Jr. [Cl. 138-78.] Single-face corrugated is formed with the corrugations running the length of the board web, and is used to form a wound multi-ply tube.

Marti, Reuben A. Fourdrinier paper making machine. U. S. patent 2,893,486. Filed Feb. 27, 1956. 11 claims. Assigned to Crown Zellerbach Corp. [Cl. 162-352.] The elimination of table rolls is made possible by the use of a single low-vacuum large-area suction box.

Miaskoff, Leonard. Clutch for printing machine. U. S. patent 2,893,730. Filed Oct. 29, 1957. 1 claim. Assigned to Davidson Corp. [Cl. 271-26.] The movement of the sheet-feeding means is halted so that the means do not interfere with replacement of the printing plate.

Murphy, Patrick J. Wrapped sandwiches and wrapper therefor. U. S. patent 2,893,876. Filed April 2, 1957. 5 claims. Assigned to Schneithorst Catering Co. [Cl. 99-171.] The wrapper is greaseproof paper imprinted with means indicating the type of sandwich contained.

Opderbeck, Fritz, Franke, Erwin, and Trapp, Günter. Method for producing alcohol from waste sulphite cellulose liquors. U. S. patent 2,893,919. Filed Aug. 23, 1955. 7 claims. Assigned to Phrix-Werke A. G. [Cl. 195-39.]

Perzentka, Thomas R. Sheet separating mechanism for duplicators. U. S. patent 2,893,729. Filed April 29, 1957. 12 claims. Assigned to A. B. Dick Co. [Cl. 271-21.]

Richter, George A., and Lamb, Arthur B. Special papers. U. S. patent 2,893,754. Filed Feb. 29, 1944. 5 claims. Assigned to U. S. Secretary of the Navy. [Cl.281-38.] Paper coated with hydroxyethylcellulose and then printed permits destruction of the printed indicia by immersing the sheet in water.

Rinker, Royden C., and Schnabel, Herbert W. Coated abrasive article and method of manufacture. U. S. patent 2,893,854. Filed Dec. 31, 1956. 11 claims. Assigned to Armour and Co. [Cl. 51-298.] An abrasive paper has a film of ethylcellulose carrying zinc stearate particles coated over the abrasive particles.

Sakornbut, Songe S. Impregnating composition. U. S. patent 2,893,881. Filed June 1, 1954. 19 claims. Assigned to Monsanto Chemical Co. [Cl. 106-15.] A water, fire-, fungi-, and insect-resistant composition consists of mineral spirits, pentachlorophenol, chlorinated paraffin, and cresyl diphenyl phosphate.

Sandmeyer, Ernest R. Package for globular articles and method of forming same. U. S. patent 2,893,550. Filed June 7, 1956. 3 claims. [Cl. 206-65.] Applies or the like are sealed between sheets of plastic and a paper handle is applied to the assembly.

Schubert, Paul. Continuous production of cellulose solution. U. S. patent 2,893,884. Filed Oct. 27, 1955. 4 claims. Assigned to J. P. Bemberg A. G. [Cl. 106-167.] A cellulose solution for use in the caum process of producing regenerated cellulose is prepared.

Schuetz, Clyde C., and Ericson, Richard. Intumescent fire-retarding bituminous coating composition and roofing made therefrom. U. S. patent 2,893,889. Filed April 2, 1956. 6 claims. Assigned to United States Gypsum Co. [Cl. 117-30.] Glass fibers are included in an asphalt coating applied to a roofing felt.

Schwertfeger, Walter J. Egg cartons. U. S. patent 2,893,-619. Filed Feb. 1, 1957. 1 claim. [Cl. 229-29.] A retail egg pack is formed by breaking up an egg flat into sections and inserting the sections into open-end sleeves.

Schytil, Franz. Process for treating comminuted solids with gases. U. S. patent 2,893,839. Filed March 5, 1957. 2 claims. Assigned to Metallgesellschaft A.G. [Cl. 23-177.] A process for roasting pyrites is described.

Shaw, Ernest C., Frank, Orville C., and Jackson, Clifford C. Hydraulic debarker having automatically controlled log speed and nozzle spacing, stroke and speed. U. S. patent 2,893,452. Filed Aug. 8, 1957. 10 claims. Assigned to Filer & Stowell Co. [Cl. 144-208.]

Shouvlin, Joseph C., and Ginaven, Marvin E. Combined digestion and refining of paper pulp. U. S. patent 2,893,909. Filed June 9, 1954. 10 claims. Assigned to Bauer Bros. Co. [Cl. 162-17.]

Soffa, Albert, and Kulicke, Frederick W., Jr. Automatic folding and binding machine. U. S. patent 2,893,297. Filed Feb. 25, 1957. 4 claims. Assigned to Walter S. Sachs & Co., Inc. [Cl. 93-84.]

Stell, George H. Web dispenser. U. S. patent 2,893,616. Filed Oct. 25, 1957. 3 claims. Assigned to Precision Metal Workers. [Cl. 225-52.] A wall-mounted dispenser for waxed paper or the like is provided.

Stidwill, George B. M. Load leveller. U. S. patent 2,894,147. Filed Nov. 26, 1956. 5 claims. Assigned to Howard Smith Paper Mills Ltd. [Cl. 250-234.] Photoelectric controls are provided for an automatically lowered layboy for receiving paper sheets from a web-cutting or printing machine or the like.

Suen, Tzeng J., and Russell, William N. Tripolymer and starch clay adhesive composition containing same. U. S. patent 2,893,977. Filed Nov. 10, 1955. 12 claims. Assigned to American Cyanamid Co. [Cl. 260-17.4.] The water resistance of a converting adhesive is increased.

Tann, David. Wiring board and method of construction. U. S. patent 2,893,150. Filed Dec. 22, 1955. 6 claims. [Cl. 41-24.] A printed circuit is formed.

Tebbutt, Eric. Packaging of liquids. U. S. patent 2,893,187. Filed May 27, 1957. 3 claims. Assigned to Rose Brothers (Gainsborough) Ltd. [Cl. 53-180.] Liquids are packed in a system in which a tube of packaging material is formed into a tube and sealed transversely to form pouches which are filled simultaneously.

Toensmeier, Patrick A. Carrier cartons. U. S. patent 2,-893,593. Filed June 19, 1957. 4 claims. Assigned to New Haven Board & Carton Co. [Cl. 220-115.] A partitioned bottle carrier is constructed to conserve board.

Wiedow, James C. Wetting and dispersing agents containing a water-soluble lignosulfonic acid salt. U. S. patent 2,893,913. Filed Aug. 29, 1955. 11 claims. Assigned to Monsanto Chem. Co. [Cl. 167-42.] A biocide preparation also includes the use of tall oil and rosin acids.

Williamson, Marshall I. Hollow walled folding boxes. U. S. patent 2,893,620. Filed Oct. 30, 1953. 3 claims. [Cl. 229-34.]

Yovanovich, Joseph T. Apparatus for winding tubes. U. S. patent 2,893,296. Filed May 17, 1956. 3 claims. [Cl. 93-80.] A mandrel for winding paper tubes is designed to prevent slippage between the mandrel and the paper strips.

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Ambrose, Francis X. Process of making reinforced plastic panels and article produced thereby. U. S. patent 2,894,621. Filed Aug. 17, 1956. 12 claims. Assigned to Alsynite Co. of America. [Cl. 206-60.] Resin-impregnated glass fiber mats are laminated and totally sealed within envelopes of cellophane.

Andersson, Nils. Method and apparatus for extrusion coating and product. U. S. patent 2,894,853. Filed July 5, 1956. 2 claims. [Cl. 117-11.] In coating paper with polyethylene and the like, the appearance of edge beads is avoided.

Bamburg, Robert A. Shipping container. U. S. patent 2,894,672. Filed July 30, 1957. 4 claims. Assigned to Olin Mathieson Chem. Corp. [Cl. 229-27.] A partitioned ventilated stackable paperboard shipping container is provided for small berry boxes.

Belton, Maurice L., and Rowand, Harold E. Prefolding device. U. S. patent 2,894,434. Filed Jan. 6, 1955. 4 claims. Assigned to Crown Zellerbach Corp. [Cl. 93-49.] The device provided prefolds a score line of a certain type of container blank.

Braunlich, Richard H. Method of forming crimped artificial filaments. U. S. patent 2,894,802. Filed Nov. 16, 1955. 8 claims. Assigned to Am. Viscose Corp. [Cl. 18-54.] These are rayon filaments.

Campbell, Claude N., Jr. Bulk dispensing container. U. S. patent 2,894,666. Filed March 5, 1956. 6 claims. [Cl. 222-528.] A paperboard shipping container for chemicals in any pourable form is provided with means for dispensing the material through the bottom of the container.

Cargill, Sylvester H., and Harkess, William L. Wrapping machine. U. S. patent 2,894,362. Filed Feb. 20, 1953. 3 claims. Harkess' interest assigned to Cargill. [Cl. 53-182.] Several articles are entubed in wrapping material which is then sealed and severed between the articles to form individual packs.

Dubinsky, Milton. Pneumatic edge guider. U. S. patent 2,894,743. Filed Jan. 23, 1956. 14 claims. Assigned to Milton

Dubinsky, Sanford Kroll, and George Kroll. [Cl. 271-2.6.] Pneumatic means adjust the transverse position of a web of paper being fed to a printing press.

Duke, James B. Clay brightness by flotation. U. S. patent 2,894,628. Filed July 13, 1956. 11 claims. Assigned to Minerals & Chemicals Corp. of America. [Cl. 209-166.] A froth flotation treatment (in which tall oil is used) improves the brightness of kaolin clay for use in papermaking.

Eckstein, Morris. Carton flap clamp. U. S. patent 2,894,308. Filed April 15, 1957. 4 claims. [Cl. 24-259.] A clip device holds the carbon flaps open during the filling operation.

Fielding, Francis W. Article carrier. U. S. Reissue patent 24,667. Filed Nov. 3, 1958. 6 claims. Assigned to Lengsfield Brothers, Inc. [Cl. 206-65.] A tubular open-end can carrier is provided.

Foote, James E. Molding pulp articles. U. S. patent 2,894,869. Filed Aug. 6, 1956. 4 claims. Assigned to Diamond Gardner Corp. [Cl. 162-224.] Partial drying followed by compression between heated dies imparts a smooth surface finish to the article.

Friedman, Harry J. Pad books. U. S. patent 2,894,767. Filed Sept. 13, 1957. 2 claims. [Cl. 281-15.] A paper calendar pad is spiral-bound at the top and provided with a side-opening cover.

Gallo, Alfredo. Cigarette and match package. U. S. patent 2,894,619. Filed April 7, 1958. 3 claims. [Cl. 206-48.] The front face of a flip-top cigarette pack opens to provide access to a compartment containing matches.

Gempe, Erich, and Heimlich, Ernst. Loose leaf binders. U. S. patent 2,894,513. Filed Jan. 30, 1956. 4 claims. Assigned to F. Soennecken. [Cl. 129-11.]

Goumeniouk, Gleb I. Fluid stock distributor. U. S. patent 2,894,581. Filed March 26, 1957. 16 claims. Assigned to Rice Barton Corp. [Cl. 162-339.]

Hampton, Burt L. Progress for upgrading polymerized fatty acid mixtures. U. S. patent 2,894,939. Filed Sept. 23, 1957. 14 claims. Assigned to Glidden Co. [Cl. 260-97.7.] Chlorides are removed from tall oil fatty acid polymers.

Hassler, John W., Westley, Oren A., and Filicky, Joseph G. Manufacture of active carbon from anthracite coal. U. S. patent 2,894,914. Filed April 30, 1957. 16 claims. Assigned to West Virginia Pulp and Paper Co. [Cl. 252-445.]

Hatcher, Glenn B. Carton erecting machine. U. S. patent 2,894,432. Filed May 2, 1957. 11 claims. Assigned to Bloomer Bros. Co. [Cl. 93-37.] An automatic machine is provided for erecting cellular paperboard egg cartons.

Hofreiter, Bernard T., Wolff, Ivan A., and Mehltretter, Charles L. Dicarboxyl starches and method of preparation. U. S. patent 2,894,945. Filed Dec. 19, 1956. 3 claims. Assigned to U. S. Secretary of Agr. [Cl. 260-233.3.] The starches are of use in paper sizes and adhesives.

Holmes, Arthur H., Holmes, Fred, and Holmes, Amos L. Letterpress machines or cutting and creasing machines, of the vertical type. U. S. patent 2,894,745. Filed Feb. 7, 1957. 1 claim. [Cl. 271-62.] Improved feed and delivery tables are provided.

Lindeke, Charles B. Envelope construction. U. S. patent 2,894,676. Filed Aug. 20, 1956. 2 claims. Assigned 50% to Charles A. Bowes. [Cl. 229-73.] Various modifications in the design of an envelope closure flap permit it to be used as a send-and-return mailer.

Nagler, Stanley E. Car load. U. S. patent 2,894,461. Filed March 14, 1955. 5 claims. [Cl. 105-367.] A system is described for loading a railroad car or truck with cartons.

Nelson, Melvin C., and Hess, Paul S. Surface covering product and process therefore. U. S. patent 2,894,560. Filed April 15, 1955. 10 claims. Assigned to Congoleum-Nairn Inc. [Cl. 154-25.] A tall oil derivative is used in forming linoleum.

Nicholls, Herbert C. Palletized container. U. S. patent 2,894,671. Filed Jan. 26, 1956. 3 claims. Assigned to Consolidated Water Power & Paper Co. [Cl. 229-14.] A container is provided with a pallet-forming bottom portion, all elements being formed of paperboard.

Paschall, Eugene F. Nitrogen containing starch derivatives. U. S. patent 2,894,944. Filed Nov. 14, 1956. 6 claims. Assigned to Corn Prods. Co. [Cl. 260-233.3.] The product is of use in sizing paper or the like; the process is adaptable to the modification of cellulose.

Peters, Chester, and Seybold, Floyd B. Partition assembly machine. U. S. patent 2,894,433. Filed July 16, 1957. 6 claims. [Cl. 93-38.]

Puckett, Ralph Q., and Ashlock, Loma E. Log handling tongs. U. S. patent 2,894,782. Filed Sept. 20, 1954. 16 claims. [Cl. 294-110.]

Rockoff, Joseph. Synthetic elastomeric composition containing butadiene-styrene and a rosin soap. U. S. patent 2,894,924. Filed June 19, 1953. 5 claims. Assigned to Dayton Rubber Co. [Cl. 260-27.]

Simkins, Daniel. Pouring device for bulk containers. U. S. patent 2,894,661. Filed Dec. 6, 1957. 10 claims. Assigned to Continental Can Co., Inc. [Cl. 222-176.] The container is mounted on palletlike runners and a length of flexible tubing is affixed to a dispensing opening located in the bottom of the container.

Sisson, Edmond F., Cole, Richard F., and Krumbein, Jacob P. Method of fractionating tall oil into fatty acids and rosin acid products. U. S. patent 2,894,880. Filed Sept. 12, 1955. 10 claims. Assigned to Heyden Newport Chem. Corp. [Cl. 202-52.] A fractional distillation process emphasizes removal of odoriferous substances.

Sperry, Russell L. Production of synthetic resinous materials by acid charring of lignins. U. S. patent 2,894,940. Filed March 30, 1956. 23 claims. [Cl. 260-124.] A drilling mud additive is produced by treating lignins from spent pulping liquors with strong mineral acid.

Stein, Sam. Self-attaching disposable litter bag. U. S. patent 2,894,675. Filed July 5, 1957. 1 claim. [Cl. 229-53.] A paper bag is provided with adhesive means for attaching the bag to the dashboard of an auto and for sealing the bag after it is filled.

Sullivan, Robert E., and Gregory, William T. Antifoam emulsion. U. S. patent 2,894,913. Filed Feb. 20, 1958. 2 claims. Assigned to Dow Corning Corp. [Cl. 252-358.] Methylcellulose is used.

Thumim, Carl. Hand wheel assembly for back gauge of paper cutters. U. S. patent 2,894,479. Filed May 24, 1957. 3 claims. Assigned to E. P. Lawson Co. Inc. [Cl. 116-115.]

Ullman, Fred E., Klopfenstein, King L., and Novotny, George F. Process and apparatus for applying covers to containers. U. S. patent 2,894,361. Filed April 15, 1955. 6 claims. Assigned to Triangle Package Machinery Co. [Cl. 53-40.] Circular flanged edge paper covers are applied to cylindrical paper containers at high speed.

Vuillemenot, Robert P. Cardboard boxes. U. S. patent 2,894,673. Filed Sept. 11, 1958. 2 claims. Assigned to Maiden Form Brassiere Co., Inc. [Cl. 229-36.] A carton formed from a single blank includes partially telescoping and hinged body and cover portions.

Wagaman, Merle L. Reclosable carton end construction. U. S. patent 2,894,674. Filed July 11, 1958. 10 claims. Assigned to Fibreboard Paper Products Corp. [Cl. 229-43.] A reclosable end closure construction is provided in a paperboard display carton for bakery goods or the like.

Wilhelm, Robert J., and Waugaman, Charles A. Method of making breathable vinyl resin coated fabric. U. S. patent 2,894,855. Filed April 19, 1956. 8 claims. Assigned to B. F. Goodrich Co. [Cl. 117-103.]

Wimmer, Ernest L., and Meindl, Frank. Art of manufacturing cold water dispersible adhesives. U. S. patent 2,894,859. Filed May 3, 1957. 3 claims. Assigned to Chas. A. Krause Milling Co. [Cl. 127-33.] The starch adhesive prepared is for use in forming gypsum board.

Wright, Roy E. Water-resistant adhesive compositions. U. S. patent 2,894,847. Filed April 22, 1955. 4 claims. Assigned to Philadelphia Quartz Co. of Calif. [Cl. 106-79.] A paper-converting adhesive comprises a soy protein fraction dispersed in a solution of sodium silicate.

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Anderson, Emil, Manor, Briarcliff, and Kowalewski, John J. Apparatus for making container closures. U. S. patent 2,895,551. Filed Dec. 20, 1952. 1 claim. Assigned to Electrolux Corp. [Cl. 164-68.] The machine assembles a self-closing closure element for attachment to the open mouth of a paper filter bag for vacuum cleaners.

Ault, Waldo C., and Feuge, Renben O. Monoglyceride diacetates. U. S. patent 2,895,966. Filed April 12, 1954. 4 claims. Assigned to the United States of America as represented by the Secretary of Agriculture. [Cl. 260-348.] These may be tall oil derivatives; they are used to plasticize cellulose nitrate and the like.

Bachus, Benson F. Pressure valve and control system for paper pulp machines. U. S. patent 2,895,505. Filed Aug. 31, 1954. 6 claims. Assigned to Western Electric Co., Inc. [Cl. 137-563.] A constant pressure stock system is provided for use with several machines which mold the pulp as insulation about electrical conductors.

Bader, Alfred R., and Vogel, Henry A. Acetoacetic acid esters of castor oil and the use thereof in plasticization. U. S. patent 2,895,844. Filed Nov. 12, 1954. 3 claims. Assigned to Pittsburgh Plate Glass Co. [Cl. 106-195.] These products are used to plasticize cellulose nitrate.

Bailey, Donald L., and York, Edward R. Siloxane water repellent treatment for fibrous materials. U. S. patent 2,895,853. Filed May 3, 1955. 15 claims. Assigned to Union Carbide Corp. [Cl. 117-155.]

Beachler, Edward D. Machine drive. U. S. patent 2,895,348. Filed Jan. 21, 1958. 13 claims. Assigned to Beloit

Iron Works. [Cl. 74-689.] Various improvements are made in a paper machine drive in order to reduce the severe wear commonly experienced during starting and stopping operations.

Beck, William J., and Fazendin, Donald F. Photographic slide clip. U. S. patent 2,895,247. Filed Sept. 16, 1957. 1 claim. Assigned to Minneapolis-Honeywell Regulator Co. [Cl. 40-152.] A paperboard photo transparency mount is provided with aluminum reinforcement.

Bevarly, Henry W., and Yann, Carl C. Method of and apparatus for producing packages of plastic material at high cyclic rates. U. S. patent 2,895,271. Filed May 18, 1956. 22 claims. Assigned to Chemetron Corp. [Cl. 53-21.] Butter or the like is formed into blocks and the blocks are wrapped.

Biel, Hans, Pfäffle, Ernst, and Bertsch, Fritz. Apparatus for making articles stitched along a fold. U. S. patent 2,895,730. Filed April 29, 1955. 7 claims. Assigned to Hans Sickinger. [Cl. 270-37.] In making pamphlets, the folding is accomplished prior to the stitching.

Bilger, Xavier, and Muller, Paul. New complex solutions and dispersions and process for their preparation. U. S. patent 2,895,837. Filed Dec. 26, 1956. 3 claims. Assigned to Comagnie Francaise des Matieres Colorantes. [Cl. 106-18.] The materials claimed may be used to treat paper to improve resistance to water, fire, and fungi.

Blaess, A. Albert. Packaging material. U. S. patent 2,895,270. Filed Nov. 14, 1955. 7 claims. Assigned to Minnesota Mining and Mfg. Co. [Cl. 53-21.] A heat-sealable V.P.I. paper is provided.

Brav, Milton. Novelty package. U. S. patent 2,895,834. Filed Aug. 2, 1955. 8 claims. Assigned to Sue Ann Food Products Corp. [Cl. 99-171.] Cheese is packed in a carton beneath a device simulating a beer bottle.

Brooks, Alfred J., and Strickland, John S. Device to open and hold containers during packaging operation. U. S. patent 2,895,276. Filed March 8, 1955. 5 claims. Strickland's interest assigned to Brooks. [Cl. 53-261.] The containers are bags.

Budd, Larry J. Means for supporting apparatus for shipment. U. S. patent 2,895,661. Filed May 17, 1954. 3 claims. Assigned to Pallet Devices, Inc. [Cl. 229-14.] A shipper for TV sets is provided with a pallet bottom and various interior packing members.

Caldwell, John R., and Martin, James C. Esters of 4-(4′-Tolyl-sulfonyl)-benzoic acid and resinous compositions plasticized therewith. U. S. patent 2,895,842. Filed Feb. 13, 1956. 8 claims. Assigned to Eastman Kodak Co. [Cl. 106-179.] Cellulose esters are plasticized.

Callear, Thomas E., and O'Brien, Albert S. Photographic paper base. U. S. patent 2,895,827. Filed Oct. 24, 1956. 10 claims. Assigned to Eastman Kodak Co. [Cl. 96-85.] The wet-strength paper is surface sized to prevent migration of the formaldehyde (from the wet-strength agent) to the photosensitive coatings subsequently applied.

Cone, James E. Mailing and return device. U. S. patent 2,895,664. Filed Aug. 15, 1956. 2 claims. [Cl. 229-73.] The mailers are provided in the form of a continuous strip for handling by business machines.

Filsinger, Jamieson A., and Braun, Philip N. Machine for affixing identification tags. U. S. patent 2,895,388. Filed June 9, 1958. 8 claims. Assigned to Textile Marking Machine Co., Inc. [Cl. 93-88.] Various improvements are made in a machine for stapling paper tags to garments.

Ford, Barton H. Freight car bulkhead. U. S. patent 2,895,431. Filed April 22, 1957. 2 claims. Assigned to Ford Grain Door Co. [Cl. 105-369.] Corrugated board is used to form the bulkhead of a grain car.

Fourmanoit, Robert. Method of and apparatus for removing from a mandrel, by means of compressed air, fibrocement tubes produced with tube-making machines and the like. U. S. patent 2,895,867. Filed May 16, 1956. 1 claim. Assigned to Eternit Soc. p. Az. [Cl. 162-118.]

Freeman, Stephan E. Use of cellular material in packaging articles. U. S. patent 2,895,603. Filed Jan. 15, 1957. 14 claims. Assigned to Freeman Chemical Corp. [Cl. 206-46.] The article to be packed is placed in a plastic bag, the bag is placed in a carton, and a polyurethane foam is formed *in situ* in the carton about the bag.

Gelleke, Gerrit De. Carrier for rotary knife for web-slitting machine. U. S. patent 2,895,553. Filed March 5, 1956. (Divided; original field June 28, 1955.) 1 claim. Assigned to Cameron Machine Co. [Cl. 164-70.]

Hall, Harry H. Process of producing all skin rayon. U. S. patent 2,895,787. Filed Dec. 30, 1954. 6 claims. Assigned to Am. Viscose Corp. [Cl. 18-54.] The coagulation modifier is a phosphoric acid ester of an alkylene oxide adduct of a higher aliphatic alcohol.

Hamada, Tsugio. Quinidine gluconate sustained medication tablet. U. S. patent 2,895,881. Filed April 4, 1957. 2 claims. Assigned to Wynn Pharmacal Corp. [Cl. 167-82.] Ethylcellulose is used.

Hartford, Willis G., Holt, Joseph W., and Jellinek, Ernest. Apparatus for detecting defects in sheet materials. U. S. patent 2,896,196. Filed May 18, 1955. 1 claim. Assigned to Champion International Co. [Cl. 340-259.] Improvements are made in an apparatus for continuously detecting and recording or otherwise displaying variations in the thickness of a web of paper or the like.

Hoag, Roderick W. Commodity packets. U. S. patent 2,895,606. Filed Sept. 25, 1956. 1 claim. [Cl. 206-56.] Multi-pocket packets for small quantities of tea, sugar, or the like are formed.

Hockett, Carl G. Manufacture of peated filters, U. S. patent 2,895,174. Filed Jan. 10, 1957. 6 claims. Assigned to Fram Corp. [Cl. 18-59.] An improved method of assembly is provided for air filters comprising a pleated paper annulus between inner and outer screens, with the ends of the paper and screens embedded in plastic caps.

Hollis, Albert C. Machines for inserting packing material into bottles. U. S. patent 2,895,275. Filed July 11, 1956. 12 claims. Assigned to B. U. Supplies & Machinery Co., Ltd. [Cl. 53-59.] The machine inserts crinkled paper or the like into the top of a partially filled bottle.

Howsmon, John A. Method of forming all skin viscose rayon. U. S. patent 2,895,788. Filed Dec. 30, 1954. 8 claims. Assigned to American Viscose Corp. [Cl. 18-54.] Choline or certain choline salts are used as coagulation modifiers.

Humphner, Ferdinand W. Filament reinforced gummed tear-tape. U. S. patent 2,895,865. Filed Aug. 26, 1955. 7 claims. Assigned to Minnesota Mining and Mfg. Co. [Cl. 154-53.5.]

Kennedy, Walter I. Disposable separable lock for safety pins. U. S. patent 2,895,196. Filed Dec. 6, 1954. 2 claims. [Cl. 24-156.] A gummed paper device forms a cover guard for the head of a safety pin.

Krukonis, Alexander C. Method of assembling and wrapping articles. U. S. patent 2,895,272. Filed July 18, 1957. (Original filed June 25, 1956.) 3 claims. Assigned to Crompton & Knowles Corp. [Cl. 53-21.] This is similar to U. S. patent 2,895,601 (July 21, 1959).

Krukonis, Alexander C. Package of articles. U. S. patent 2,895,601. Filed June 25, 1956. 1 claim. Assigned to Crompton & Knowles Corp. [Cl., 206-45.31.] A cigarette carton leaves the ends of the packs exposed for tax marking.

Lepin, Maurice. Process for incorporating titanium dioxide into cellulose ester solutions dissolved in aliphatic acids. U. S. patent 2,895,843. Filed July 8, 1957. 5 claims. Assigned to Societe Rhodiaceta. [Cl. 106-180.]

Magill, Donald G., Jr. Method of making resin impregnated paper. U. S. patent 2,895,868. Filed Jan. 26, 1955. 7 claims. Assigned to Riegel Paper Corp. [Cl. 92-21.] A beater-additive method is described; the product is for use in oil filters.

Mazzio, Anthony J., Niesen, George P., Engelstad, George E., and Du Bois, Edgar H. Feed mechanism and interrupter for duplicating machines. U. S. patent 2,895,416. Filed May 10, 1954. 6 claims. Assigned to A. B. Dick Co. [Cl. 101-245.]

Mergenthaler, Edward C. Display post supports. U. S. patent 2,895,696. Filed April 1, 1955. 6 claims. Assigned to Waldorf Paper Products Co. [Cl. 248-158.] Certain paperboard elements are provided for use in a merchandising display.

Miller, Alexander A. Cellulosic materials. U. S. patent 2,895,891. Filed May 15, 1957. 13 claims. Assigned to General Electric Co. [Cl. 204-154.] The materials (such as methylcellulose) are crosslinked by ionizing radiation.

Northgraves, Walter W., and Nicolaisen, Bernard H. Process for producing chlorine dioxide. U. S. patent 2,895,801. Filed April 6, 1956. 15 claims. Assigned to Olin Mathieson Chemical Corp. [Cl. 23-152.]

Paige, Richard E. Gift boxes. U. S. patent 2,895,663. Filed June 11, 1956. 1 claim. [Cl. 229-35.] The walls are reinforced by the interlocking required in the setting up of the box.

Pomper, Anthony W., and Waechter, Charles J. Transverse web cutting apparatus having sheet delivery mechanism using timed vacuum belts. U. S. patent 2,895,552. Filed Aug. 10, 1955. 12 claims. Assigned to John Waldron Corp. [Cl. 164-68.]

Robinson, Paul C., and Staffileno, Arch L. Multiply bag with supplemental sleeve. U. S. patent 2,895,387. Filed Dec. 7, 1956. 5 claims. Assigned to Arkell and Smiths. [Cl. 93-8.]

Rodman, James B. Apparatus for cutting flattened containers. U. S. Reissue patent 24,668. Filed Feb. 19, 1959. 38 claims. Assigned to Weyerhaeuser Timber Co. [Cl. 93-58.4.] The apparatus cuts off end portions of certain of the closure flaps of the flattened carton.

Seltman, Paul R. Ground surfaced laminated paper tubes. U. S. patent 2,895,511. Filed Oct. 14, 1955. 3 claims. As-

signed to Crescent Paper Tube Co., Inc. [Cl. 138-76.] A spiral-wound paper tube is prepared for use as a core for a roll of plastic film.

Spivack, Stanley. Bench made of corrugated board. U. S. patent 2,895,541. Filed April 18, 1958. 1 claim. [Cl. 155-169.]

Steidinger, Donald J. Mechanism for adhering gummed tape to the top flaps of an envelope assembly in continuous form. U. S. patent 2,895,534. Filed May 24, 1956. 11 claims. Assigned to Uarco Inc. [Cl. 154-1.6.]

Vines, Oscar L. Carton. U. S. patent 2,895,662. Filed Oct. 25, 1954. 4 claims. Assigned to Continental Paper Co. [Cl. 229-28.] A cellular fruit box is designed so as not to lose its shape when wet.

Wade, Worth. Apparatus for recovering waste coated fibers. U. S. patent 2,895,176. Filed Oct. 24, 1956. (Divided; original filed June 2, 1952.) 6 claims. Assigned to American Viscose Corp. [Cl. 19-66.] The fibers of waste filter batts carrying deposits of cellulose acetate are recovered and formed into paper and other useful products.

Whelan, James P. Infusion bag. U. S. patent 2,895,598. Filed Sept. 14, 1956. 1 claim. Assigned to Pneumatic Scale Corp., Ltd. [Cl. 206-.5.] The tag is heat-sealed to the bag in nontangling position.

Wilson, Harry W. Method of packaging K.D.F. cartons. U. S. patent 2,896,207. Filed April 9, 1957. 10 claims. [Cl. 53-3.] A stack of collapsed cartons is banded together with two lower runner elements so that the bale may be handled by fork-life truck.

Wilson, Harry W. Self-palletized package. U. S. patent 2,895,608. Filed April 9, 1957. 13 claims. [Cl. 206-56.] This is similar to U. S. patent 2,896,207 (July 21, 1959).

Youngren, Milton D. Animated card device. U. S. patent 2,895,244. Filed July 29, 1958. 7 claims. [Cl. 40-126.] A greeting card is described.

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Altenburg, William M. Bottle carrier. U. S. patent 2,896,814. Filed Dec. 12, 1957. 2 claims. Assigned to Diamond Gardner Corp. [Cl. 220-116.] A carrier for three bottles arranged in a single row is formed of molded pulp.

Aronson, Ben J. Apparatus for covering wire garment hangers. U. S. patent 2,896,383. Filed June 26, 1956. 45 claims. Assigned to Aronson Hanger Covers, Inc. [Cl. 53-51.] The hangers are covered with paper.

Back, Leonard, and Haas, Walter. Folding device for paperboard carriers. U. S. patent 2,896,382. Filed Feb. 23, 1956. 13 claims. Assigned to The Interstate Folding Box Co. [Cl. 53-48.] Folding means are provided in a machine for setting up an open-end six-pack can carrier.

Barnes, James F., and Rebholz, Elmer F. Package for drink-forming powders. U. S. patent 2,896,839. Filed July 26, 1955. 1 claim. Assigned to Foil Process Corp. [Cl. 229-62.] A waxed paperboard container is filled with a small charge of powdered milk and then sealed and collapsed to envelope shape.

Barratt, Harold, Forrester, Thomas N., and Wilson, George H. Sheet feeding apparatus. U. S. patent 2,896,946. Filed Jan. 7, 1957. 12 claims. Assigned to Courtaulds Ltd. [Cl. 271-6.] Stack-replenishing means are provided in an apparatus feeding pulp sheets to a viscose process slurrying tank.

Bergstein, Frank D. Carton with self-sealing end closures. U. S. patent 2,896,836. Filed Dec. 14, 1956. 3 claims. Assigned to Bergstein Pkg. Trust. [Cl. 229-37.]

Burkhardt, George C., Eastwood, Clinton, and Hamilton, Joseph P. Stacking tray and handle therefor. U. S. patent 2,896,835. Filed Aug. 7, 1956. 3 claims. Assigned to Container Corp. of America. [Cl. 229-34.] This is a berry tray to which may be attached handle elements which also serve as interlocks when the trays are stacked.

Campbell, Howard N. Method of and apparatus for forming hoisery package. U. S. patent 2,896,380. Filed March 16, 1956. 16 claims. Assigned to Paramount Textile Machinery Co. [Cl. 53-3.] The apparatus provided telescopes two socks one over the other and both over a supporting paperboard blank.

Celley, Albert F. Article handling pallet means. U. S. patent 2,896,798. Filed Nov. 18, 1953. 1 claim. Assigned to Owens-Illinois Glass Co. [Cl. 214-10.5.] A pallet for unitizing carton loads is formed from a single paperboard sheet.

Cronin, John P., and Hennig, Arnold J. Low viscosity CMC pharmaceutical vehicle. U. S. patent 2,897,120. Filed May 4, 1954. 20 claims. Assigned to The Upjohn Co. [Cl. 167-82.]

Curran, Frank J. Packaged insect repellent. U. S. patent 2,896,853. Filed Jan. 10, 1958. 7 claims. [Cl. 239-57]. A solid block of repellent is packaged in a carton having openings in the side walls.

de Ganahl, Carl. Methyl cellulose coated polyester tape. U. S. patent 2,897,099. Filed Aug. 31, 1955. 2 claims. [Cl. 117-138.8.]

Demarest, Daniel D. Brick packages. U. S. patent 2,896,781. Filed Aug. 23, 1956. 1 claim. [Cl. 206-65.] Layers of bricks are supported on paper trays and the entire assembly is bound with strips of pressure-sensitive tape.

Dungler, Julien. Drying of fabrics, papers, cardboards, and other lengthy materials. U. S. patent 2,896,335. Filed July 24, 1956. 7 claims. [Cl. 34-68.] The drying is effected by steam and radiant elements, with the steam also being heated by the radiant elements.

Ehrisman, Henry O., and Drinker, Henry S. Digester relief system. U. S. patent 2,896,709. Filed May 11, 1956. 1 claim. Assigned to The Foxboro Co. [Cl. 162-238.]

Ferguson, John L., Sr., and Talbot, Richard C. Apparatus for applying ahesive to the flaps of cases or cartons. U. S. patent 2,896,569. Filed May 7, 1957. (Divided; original filed Jan. 19, 1954.) 5 claims. Assigned to J. L. Ferguson Co. [Cl. 118-3.]

Fleming, Margaret E. Dental cleaners. U. S. patent 2,896,639. Filed Oct. 1, 1956. 1 claim. Assigned to John S. Fleming. [Cl. 132-93.] These are formed of paper coated with a silicone or wax.

Frankenstein, William P. Cake lift. U. S. patent 2,896,834. Filed Sept. 28, 1953. 1 claim. [Cl. 229-30.] Two interlocking paperboard blanks form a device for supporting a cake in an outer carton.

Fry, Stanley R., and McCormick, Denis V. Paper sheet folding machines. U. S. patent 2,896,942. Filed Feb. 5, 1957. 8 claims. Assigned to Camco (Machinery) Ltd. [Cl. 270-84.] Registering means are provided.

Gibb, Alex S. Carton making machine. U. S. patent 2,896,518. Filed Dec. 27, 1956. 18 claims. Assigned to Continental Can Co., Inc. [Cl. 93-51.] The machine provided sets up and glues a flat open-top traylike carton of the type used in packaging cans of beer.

Goss, Harold J. Box stacking apparatus. U. S. patent 2,896,519. Filed July 1, 1957. 6 claims. Assigned to International Paper Box Machine Co. [Cl. 93-51.] A channel-and-plunger type box-forming machine is provided with means to move formed boxes out of the way of the next stroke of the plunger.

Harwood, Kenneth J. Disposable absorbent pad. U. S. patent 2,897,108. Filed May 11, 1953. 1 claim. Assigned to Kimberly-Clark Corp. [Cl. 154-50.] Several tissue sheets and plastic film are combined to form a disposable handkerchief.

Harwood, Kenneth J. Sanitary napkin. U. S. patent 2,896,627. Filed June 17, 1958. 12 claims. Assigned to Kimberly-Clark Corp. [Cl. 128-290.] The product includes a barrier sheet between outer wrapper and absorbent pad; the sheet comprises a loosely creped fiber web partially embedded in a plastic film.

Hayes, Norman J., and Ross, William C. Process of treating latex impregnated paper with an isocyanate and resultant article. U. S. patent 2,897,094. Filed May 11, 1954. 6 claims. Assigned to W. R. Grace & Co. [Cl. 117-62.] The wet-strength and abrasion resistance of the paper are improved.

Hoffberger, Charles C. Foldable strainer device. U. S. patent 2,896,788. Filed Aug. 26, 1957. 1 claim. [Cl. 210-473.] Paperboard and filter paper elements are assembled to form a strainer for use in recovering passed kidney stones.

Johnson, Ralph L. Pictures mount. U. S. patent 2,896,351. Filed May 29, 1958. 2 claims. [Cl. 40-158.] The paperboard-plastic device may be used to mount either photographs or transparencies.

Labombarde, Raymond A. Multi-faced folding guide. U. S. patent 2,896,517. Filed Jan. 12, 1956. 5 claims. [Cl. 93-49.] A box blank folding machine is provided with flap hold-down means.

Laboureur, Pierre. Process of purifying and utilizing residual waters resulting from the manufacture of paper pulp prepared by the soda process. U. S. patent 2,897,148. Filed Feb. 23, 1955. 10 claims. Assigned to Société d'Etudes et d'Applications Biochimiques. [Cl. 210-11.]

Lane, Dan R. Packaging with corner saddle means. U. S. patent 2,896,832. Filed July 5, 1955. 6 claims. Assigned to Lane Container Co. [Cl. 229-14.] A corrugated blank forms an interior packing member for use in packaging a stack of glass sheets within an outer carton.

Lloyd, Arthur J., Lloyd, Grahame A., and Preston, Iris W. Diphenyl dispersions for the impregnation of paper. U. S. patent 2,897,111. Filed Dec. 28, 1955. 10 claims. Assigned to Monsanto Chemicals Ltd. [Cl. 167-30.]

Markham, Robert N. Protective corner pad for packing mirrors and the like. U. S. patent 2,896,833. Filed June 19, 1956. 2 claims. Assigned to Highland Container Co. [Cl. 229-14.] The pad is formed of corrugated paperboard.

Marks, Ronald H. Continuous process and apparatus for marking paper yarn. U. S. patent 2,896,393. Filed Jan. 16, 1957. 7 claims. [Cl. 57-32.]

Martindale, James H. Paper machinery. U. S. Reissue

patent 24,677. Filed Dec. 31, 1958. 15 claims. Assigned to The Black-Clawson Co. [Cl. 210-415.] In a cylindrical screen for paper stocks, the usual scrapers are replaced with airfoil members spaced from the screen surface.

Matter, Gustave O. Measuring dispenser. U. S. patent 2,896,826. Filed Feb. 11, 1957. 4 claims. [Cl. 222-455.] A measuring and dispensing device is disposed within a container for granulated or powdered materials.

Nord, Gustav J. Fabrication of products from *Agave lechuguilla*. U. S. patent 2,896,267. Filed Nov. 26, 1957. 5 claims. [Cl. 19-8.] The fibers obtained may be used in forming nonwoven mats or chemical or mechanical pulp.

Ortel, Gerhard. Veneer joining machine. U. S. patent 2,896,680. Filed July 26, 1957. 4 claims. Assigned to the firm Heinrich Kuper. [Cl. 144-279.] Adhesive paper tape is used to join the edges of veneer strips.

Prevost, Bruno E. Suction box cover. U. S. patent 2,896,711. Filed July 11, 1955. 6 claims. Assigned to John W. Bolton & Sons, Inc. [Cl. 162-374.]

Risucci, Edward J. Severable frozen food carton. U. S. patent 2,896,837. Filed Sept. 23, 1957. 6 claims. [Cl. 229-51.] Sections of the carton, with contents, may be removed for use while leaving the remainder of the food in an entirely closed carton.

Ryznar, John W. Chemical method of bark removal in forestry by using boroarsenates. U. S. patent 2,896,375. Filed Dec. 16, 1957. 15 claims. Assigned to National Aluminate Corp. [Cl. 47-57.5.]

Shoumatoff, Nicholas. Apparatus for drying web material. U. S. patent 2,896,336. Filed April 11, 1957. 15 claims. Assigned to West Virginia Pulp and Paper Co. [Cl. 34-86.] A paper web is carried about a porous surface drum against which it is pressed by a heated metal band while vacuum is applied from within the drum.

Snyder, George H., Jr. Automatic feed for paper box wrapping machines. U. S. patent 2,896,521. Filed Oct. 31, 1956. 3 claims. Assigned to George H. Snyder, Inc. [Cl. 93-54.]

Steen, Harford K. Paper strap and method for making same. U. S. patent 2,896,397. Filed May 25, 1955. 9 claims. Assigned to Interstate Bag Co., Inc. [Cl. 57-154.] The strap, formed of twisted and compressed paper, is to be used for making handles for shopping bags.

Struble, Glenn E. Box. U. S. patent 2,896,838. Filed Jan. 25, 1957. 2 claims. Assigned to Diamond Gardner Corp. [Cl. 229-52.] A flat hinged-cover garment box is provided with a reinforcing strip along the side wall adjacent the hinge.

Struble, Glenn E. Cartons. U. S. patent 2,896,780. Filed Jan. 13, 1956. 5 claims. Assigned to Diamond Gardner Corp. [Cl. 206-65.] A chime-engaging display carton for cans is described.

Tilton, William J., and Leslie, William T. Liner inserting device. U. S. patent 2,896,516. Filed Feb. 28, 1957. 9 claims. Assigned to Raymond Bag Corp. [Cl. 93-8.] The device provided supports a plastic film liner bag so that a multiply paper bag may be slipped over the liner.

Van Dam, Max. Heat-sensitive copying paper. U. S. patent 2,897,090. Filed April 11, 1957. 12 claims. Assigned to Anken Chemical & Film Corp. [Cl. 117-36.]

Villoresi, Camillo. Method of making cushioning paper. U. S. patent 2,896,692. Filed Nov. 22, 1954. 7 claims. Assigned to Societa per Azioni Fabbriche Fiammiferi ed Affini. [Cl. 154-33.05.] A paper having zigzag rows of corrugations is produced for use in various packaging applications.

Voigtman, Edward H. Disposable absorbent pad. U. S. patent 2,896,626. Filed June 17, 1958. 9 claims. Assigned to Kimberly-Clark Corp. [Cl. 128-287.] The pad includes several creped tissue layers faced with one cover of liquid-pervious material and one cover of plastic.

Voigtman, Edward H. Plastic film product. U. S. patent 2,897,109. Filed May 31, 1955. 3 claims. Assigned to Kimberly-Clark Corp. [Cl. 154-50.] For packaging and other applications, the sheet comprises a plastic film secured to the protruding surface fibers of a loose creped cellulosic tissue.

Wells, Roger. Suction couch roll device. U. S. patent 2,896,710. Filed Oct. 16, 1956. 7 claims. Assigned to Diamond Gardner Corp. [Cl. 162-371.] The roll, including means to blow the web from the roll, includes means preventing the blowing back of water upon the web.

Woelfer, Robert O. Machine for handling cartons to be filled. U. S. patent 2,896,520. Filed Feb. 29, 1956. 13 claims. [Cl. 93-53.] The carton and carton blank feeding devices are provided with means to adjust them to handle cartons of various sizes.

Wolfson, William B., King, Paul J., Baer, Charles A., and Clough, Philip J. Method of producing aluminized paper. U. S. patent 2,897,095. Filed March 1, 1955. 5 claims. Assigned to Natl. Research Corp., and Consolidated Paper Bag Co. [Cl. 117-70.]

Woodruff, James E. Roll paper storage receptacle and dispensing holder. U. S. patent 2,896,871. Filed May 11, 1954. 10 claims. [Cl. 242-55.3.]

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Aid, Joseph J. Corrosion inhibiting container for metal articles. U. S. patent 2,898,026. Filed Feb. 1, 1954. 4 claims. Assigned to Continental Can Co., Inc. [Cl. 229-14.] V.P.I. paper is adhered to the inner surface of a carton.

Allegretti, Anthony J., and Fischer, Raymond P. Method and apparatus for preparing and binding books. U. S. patent 2,897,523. Filed Oct. 14, 1957. 3 claims. Assigned to Cuneo Press, Inc. [Cl. 11-1.]

Annis, Rupert E., Jr. Log-centering barker feeding mechanism. U. S. patent 2,897,859. Filed Jan. 4, 1956. 5 claims. Assigned to Improved Machinery, Inc. [Cl. 144-247.]

Berliner, Julius F. T. Fiber board and process of making same from desert shrubs. U. S. patent 2,898,260. Filed July 12, 1954. 9 claims. [Cl. 162-11.]

Browning, Randolph McK. Apparatus for manufacturing bag tubes. U. S. patent 2,897,730. Filed Nov. 7, 1955. 30 claims. Assigned to St. Regis Paper Co. [Cl. 93-20.] Multiply paper bags are formed.

Bush, Frederick J. Adhesive bandage. U. S. patent 2,897,961. Filed May 2, 1956. 11 claims. Assigned to Johnson & Johnson. [Cl. 206-63.2.] The exterior wrapper of a band-aid type dressing serves as the adhesive-covering sheet.

Buttery, Kenneth T. Collapsible advertising or display device. U. S. patent 2,897,977. Filed April 19, 1954. 5 claims. Assigned to Sutherland Paper Co. [Cl. 211-135.]

Byrd, Carl. Apparatus for applying closures to flexible containers. U. S. patent 2,897,643. Filed March 29, 1956. 23 claims. Assigned to Standard Pkg. Corp. [Cl. 53-59] Improved control means are provided in a machine for filling paper cups with sherbet, then applying lids to the cups.

Cannon, Madison M. Separator. U. S. patent 2,897,972. Filed March 28, 1956. 3 claims. Assigned to Bird Machine Co. [Cl. 210-512.] A vortex-type dirt separator for paper stock is constructed so as to permit passage of oversize dirt particles from the separator outlet without plugging the outlet.

Capell, Robert G., and Templin, Philip R. Wax sized paper. U. S. patent 2,898,293. Filed Dec. 28, 1953. 6 claims. Assigned to Gulf Research & Devt. Co. [Cl. 210-502.] The strength of beater-sized waxed paper is increased by including in the size a magnesium-silicate gel.

Charlton, Cyril B., Burchell, Charles K., and Loehr, Martin L. Manufacturing processes. U. S. patent 2,898,241. Filed Dec. 4, 1956. 6 claims. Assigned to Telephone Mfg. Co. Ltd. [Cl. 117-212.] A metallized coating is deposited on a cellulosic web, which is then wound to form a capacitor.

Coe, Merrill J. Carton. U. S. patent 2,898,028. Filed Aug. 27, 1957. 5 claims. Assigned to Sutherland Paper Co. [Cl. 229-36.] Improved top closure locking means are provided in a flat carton.

Ensler, Arthur S., and Friedman, Aaron. Multiple unitary frozen confection. U. S. patent 2,898,213. Filed Oct. 23, 1957. 2 claims. Assigned to Joe Lowe Corp. [Cl. 99-180.] Several interconnected frozen confection bars having handle sticks are packaged in a single carton.

Ericks, Walter P. Process of dimensionally stabilizing cellulose, composition used therefor, and article produced. U. S. patent 2,898,313. Filed Aug. 10, 1957. 27 claims. Assigned to Upson Co. [Cl. 260-17.2.]

Fotiades, Spyros M. Automatic book and sheet-binding machine. U. S. patent 2,897,522. Filed March 28, 1952. 8 claims. [Cl. 11-1.]

Gewiss, Lucien V. Filtering cartridge for liquids and gases. U. S. patent 2,897,971. Filed Nov. 12, 1954. 2 claims. [Cl. 210-493.] Several types of pleated paper filter cartridges are described.

Hanson, Thomas P. Debarking-drum construction. U. S. patent 2,897,858. Filed March 17, 1958. 12 claims. [Cl. 144-208.] A log-barking drum is constructed to achieve a stronger stiffer structure both in torsion and in bending strength than is available in contemporary designs.

Hebert, Gerard J. Soap powder measuring dispenser. U. S. patent 2,898,013. Filed May 15, 1958. 7 claims. [Cl. 222-455.] A plastic measuring dispenser attaches to a conventional soap carton.

Hmiel, Stanley E. Stable polyethylene dispersion containing no emulsifying agent and method of coating therewith. U. S. patent 2,898,233. Filed July 31, 1958. 20 claims. Assigned to Koppers Co., Inc. [Cl. 117-103.] The dispersion may be used in coating paper.

Holbrook, Robert L. Method of flameproofing cellulosic textile material with phosphorous triisocyanate or phosphoryl triisocyanate and products produced thereby. U. S. patent 2,898,180. Filed May 9, 1956. 12 claims. Assigned to Olin Mathieson Chem. Corp. [Cl. 8-116.]

Jullander, Elof I. Methods of treating cellulose. U. S. patent 2,898,333. Filed Oct. 21, 1957. 6 claims. Assigned to Mo Och Domsjo AB. [Cl. 260-212.] Improvements are made in a method of treating cellulose pulp with sodium borohydride.

Klausmann, Milton H. Combined multiple compartment container and pouring spout. U. S. patent 2,898,004. Filed Feb. 4, 1958. 2 claims. Assigned to Seal-Spout Corp. [Cl. 222-129.]

Lang, Murray J. Stapling device. U. S. patent 2,897,500. Filed Jan. 19, 1956. 3 claims. [Cl. 1-2.] Spacer elements are stapled to cartons while the carton is in collapsed form.

Lytton, Marion R. Method of preparing viscose rayon. U. S. patent 2,898,182. Filed Dec. 30, 1954. 6 claims. Assigned to American Viscose Corp. [Cl. 18-54.] An alkylene oxide adduct of N-fatty alkyl or N-aliphatic alanine is used as coagulation modifier.

Mackay, Harold A. Industrial adhesive bonding agent comprising liquid melamine modified urea formaldehyde resin. U. S. patent 2,898,324. Filed April 2, 1956. 7 claims. Assigned to Catalin Corp. of America. [Cl. 260-67.6.] This is a storage-stable laminating resin.

Majer, Christian. Method and machine for making paper tubes. U. S. patent 2,897,731. Filed Sept. 22, 1953. 8 claims. [Cl. 93-79.] The machine winds paper or board tubes for use in the textile industry.

Miller, Robert M., Lodge, James R., and Merwin, Merle C. Roofing granules and method for making. U. S. patent 2,898,232. Filed June 14, 1956. 5 claims. Assigned to Minnesota Mining and Mfg. Co. [Cl. 117-100.]

Mitchell, Reid L., Berry, James W., and Bacon, Moody, Jr. Cellulose slurry-steeping. U. S. patent 2,898,334. Filed July 26, 1955. 7 claims. Assigned to Rayonier Inc. [Cl. 260-233.] Foaming, floating, and other problems are reduced by inclusion in the steep liquor of a block copolymer of polyethylene oxide and polypropylene oxide.

Saxton, William R., and Mithel, Bharat B. Manufacture of regenerated cellulose. U. S. patent 2,898,222. Filed Jan. 30, 1956. 10 claims. Assigned to Can Internatl. Paper Co. [Cl. 106-165.] A derivative of ethylene oxide and an amine such as Rohm & Haas' Priminox 32 is used as a viscose additive to improve fatigue strength, etc., of the rayon.

Schlumbohm, Peter. Filtration equipment, especially for making coffee. U. S. patent 2,897,970. Filed March 8, 1957. 3 claims. [Cl. 210-474.] A conical paper filter is included in the construction.

Schmidt, Morton. Pallet for sheet feeding machine. U. S. patent 2,898,105. Filed Nov. 16, 1955. 2 claims. Assigned to Schmidt Lithograph Co. [Cl. 271-62.] Improved pile-changing means are provided in a sheet-feeding mechanism of the pile-elevating type.

Scholle, William R. Container for fluent materials. U. S. patent 2,898,027. Filed Dec. 4, 1956. 2 claims. Assigned to Scholle Chemical Corp. [Cl. 229-14.] A container for storage battery electrolyte comprises an outer carton within which is sealed a polyethylene bag containing the fluid.

Schur, Milton O. Impregnating device and process. U. S. patent 2,897,777. Filed Jan. 26, 1956. 6 claims. Assigned to Olin Mathieson Chem. Corp. [Cl. 118-38.] The impregnating material is passed through a slot in a container cylinder into contact with a moving web of paper or the like.

Shepardson, Roger M. Composition containing bamboo particles and thermosetting resin. U. S. patent 2,898,314. Filed Jan. 7, 1958. 1 claim. [Cl. 260-17.2.] Wood-particle board is formed.

Sherman, Clark W. Handled carton. U. S. patent 2,898,029. Filed July 19, 1956. 6 claims. [Cl. 229-41.] A collapsible open-top basketlike handled carton is provided for packaging produce for sale in self-service stores.

Simon, Eli, and Thomas, Frank W. Packaging methods. U. S. patent 2,897,641. Filed April 27, 1956. (Divided; original filed Dec. 11, 1951.) 16 claims. Assigned to Lockheed Aircraft Corp. [Cl. 53-3.] A polyurethane or phenolic foam, formed *in situ*, is used as interior packing material.

Spiller, William R., and Johnson, Thomas H. Web tension control for rotary printing press. U. S. patent 2,897,754. Filed March 21, 1957. 12 claims. Assigned to Harris-Intertype Corp. [Cl. 101-180.]

Triquet, Russell Q. Machine for splicing paper. U. S. patent 2,898,056. Filed Dec. 6, 1954. 18 claims. Assigned to Kalamazoo Vegetable Parchment Co. [Cl. 242-58.2.]

Walker, Willard F. Convolutely wound container and method of manufacture. U. S. patent 2,898,025. Filed Jan. 9, 1958. 5 claims. Assigned to Cleveland Container Co. [Cl. 229-4.5.] Lines of weakening permit the container to be separated into body and partially telescoping cover portions.

Winesett, Frank P. Bag stacking assembly for a bag making machine. U. S. patent 2,898,106. Filed May 25, 1956. 16 claims. [Cl. 271-79.]

Zackheim, Eli A. Sterile packaging. U. S. patent 2,897,962. Filed March 16, 1956. 17 claims. Assigned to Johnson & Johnson. [Cl. 206-63.5.] Superposed sheets of plastic, glassine, and diecut paperboard from a pack for a number of twisted paper dental points.

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Barnby, Herbert A. Carrier for bottles and other containers. U. S. patent 2,899,051. Filed July 10, 1957. 4 claims. Assigned to Owens-Illinois Glass Co. [Cl. 206-65.] Apertures in top and bottom panels permit the six-pack carrier to be loaded by passing it downward over the tops of the assembled group of bottles.

Beck, Robert H. Apparatus for coating and drying photographic layers. U. S. patent 2,898,882. Filed March 1, 1956. (Divided; original filed Aug. 20, 1953.) 11 claims. Assigned to E. I. du Pont de Nemours and Co. [Cl. 118-50.]

Birdseye, Clarence. Process for storing and digesting of fibrous agricultural residues. U. S. patent 2,899,350. Filed July 16, 1954. 7 claims. Assigned to Process Evaluation and Devt. Corp. [Cl. 162-90.] Straw, bagasse, and the like are stored after impregnation with caustic.

Büttner, Artur. Sheet feeding mechanism for sheet handling apparatus. U. S. patent 2,899,203. Filed Dec. 2, 1957. 8 claims. Assigned to Schnellpressenfabrik A. G. [Cl. 271-53.]

Carr, Aloysius J. Shaftless mill roll stand. U. S. patent 2,899,145. Filed Nov. 25, 1955. 5 claims. [Cl. 242-58.6.]

Collura, Peter C. Band type can carrier. U. S. patent 2,899,104. Filed Dec. 20, 1956. 2 claims. Assigned to Container Corp. of America. [Cl. 220-115.] A sleeve-type carrier is provided with central reinforcing panel and a handle element.

Cowan, Ben, and Cowan, Elijah. Rotary pulp screens. U. S. patent 2,899,064. Filed Oct. 24, 1955. 5 claims. [Cl. 210-219.] An improved rotary impeller is provided.

Crevling, Thomas V., Haag, Donald J., and Abbott, Thomas I. Thermographic copying material. U. S. patent 2,899,334. Filed May 19, 1958. 9 claims. Assigned to Eastman Kodak Co. [Cl. 117-36.] The material comprises a paper base coated with a *p*-quinone and a dihydroxybenzene compound.

Crosfield, John F., and Gold, Daniel. Register control of moving webs. U. S. patent 2,899,143. Filed March 12, 1956. 18 claims. Assigned to J. F. Crosfield Ltd. [Cl. 242-58.3.]

Currie, Grover C., Jr. Carton. U. S. patent 2,899,123. Filed June 13, 1956. 1 claim. Assigned to Decam Corp. [Cl. 229-40.] Panels enclose all six sides of a six-pack can carrier; corner portions are cut away to reveal the cans for display.

Dreier, Raymond C. Display carton. U. S. patent 2,899,048. Filed Dec. 24, 1956. 6 claims. Assigned to Dreier Brothers, Inc. [Cl. 206-45.24.] This is a display shipper, including telescoping body and cover portions, for packaging a hacksaw or similar item.

Engel, Edward W., and Dunlap, Isaac R. Flexible paper web and process of producing same. U. S. patent 2,899,353. Filed July 16, 1953. 16 claims. Assigned to Johnson & Johnson. [Cl. 162-165.] A latex-saturated paper of use in tape backings and other products is formed.

Foley, Edward A. Wrapping machine. U. S. patent 2,898,720. Filed June 8, 1955. 5 claims. Assigned to Masonite Corp. [Cl. 53-209.] The machine applies a paper wrapper to stacks of sheets of plywood, hardboard, wallboard, or the like.

Funnell, William F. Demand shear with means of alternately brake and accelerate a continuously moving web. U. S. patent 2,898,995. Filed March 29, 1954. 3 claims. Assigned to Radio Corp. of America. [Cl. 164-42.] Improved web-moving means are provided in a machine which cuts a paper web into sheets of varying length in accordance with index marks printed on the web.

Geist, William J. Upper end structure for fiber drums. U. S. patent 2,899,118. Filed Jan. 19, 1956. 10 claims. Assigned to Continental Can Co., Inc. [Cl. 229-5.7.]

Grinspoon, Harold. Open-ended carton for packaging paper cups and other articles. U. S. patent 2,899,049. Filed Sept. 1, 1955. 2 claims. Assigned to Multi-Carton Corp. [Cl. 206-65.]

Gulemi, Thomas A. Wire tagging machine. U. S. patent 2,898,719. Filed Jan. 3, 1957. 5 claims. Assigned to Sperry Rand Corp. [Cl. 53-198.]

Hensgen, Bernard T. Machine for use in the packaging of product. U. S. patent 2,898,722. Filed April 15, 1953. 17 claims. Assigned to Swift & Co. [Cl. 53-247.] The machine slices bacon and arranges the slices in shingled fashion on a paperboard backing member.

Irmscher, Hans O. Banded strong handle infusion package assembly. U. S. patent 2,899,045. Filed May 14, 1956. 10 claims. Assigned to National Tea Packing Co., Inc. [Cl. 206-5.]

Jacobs, Ridley S. Apparatus for the continuous development of light sensitive papers. U. S. patent 2,898,835. Filed Oct. 8, 1956. 6 claims. Assigned to Nig Mfg. Co. Ltd. [Cl. 95-94.] An ammonia-vapor diazotype apparatus is described.

James, Bill Y. Leg structure for gift boxes. U. S. patent 2,899,165. Filed Dec. 28, 1953. 4 claims. [Cl. 248-189.]

James, Louise. Knock-down set-up boxes. U. S patent 2,899,120. Filed Jan. 9, 1957. 2 claims. [Cl. 229-23.] A box including a body section and partially telescoping top and bottom sections is provided with improved means for locking the body section to the bottom section.

Jenkins, Albert S. Method for bonding liner materials. U. S. patent 2,899, 349. Filed Feb. 8, 1956. (Divided; original filed Jan. 26, 1953.) 6 claims. Assigned to Owens-Illinois Glass Co. [Cl. 154-138.] A method is described for producing laminated disk liners for jar closures.

Keely, Clifford D. Carton flap sealing machine. U. S. patent 2,898,820. Filed Dec. 30, 1955. 11 claims. Assigned 50% to Raymond J. Baisley. [Cl. 93-49.]

Keely, Clifford D. Machine for adhesively joining two surfaces. U. S. patent 2,898,816. Filed Feb. 19, 1953. 4 claims. Assigned 50% to Raymond J. Baisley. [Cl. 93-36.] For use in making paperboard cartons, the device tapes two panels together in edge-abutting relation.

Kindseth, Harold V. Method of making bag closure. U. S. patent 2,899,347. Filed July 21, 1954. 4 claims. Assigned to Bemis Bro. Bag Co. (Cl. 154-102.] A multi-ply paper bag is sealed with thermoplastic material extruded on both sides of the bag mouth and through perforations in the walls of the mouth.

Kranz, Carl L., and Groner, Theron A. Composition for building blocks. U. S. patent 2,899,325. Filed Sept. 25, 1956. 1 claim. [Cl. 106-93.] The composition includes sawdust, sand, cement, burned gypsum, pine rosin, and water.

Krueger, Alfred P. Tape dispenser and folder. U. S. patent 2,899,198. Filed Sept. 17, 1957. 7 claims. Assigned to Derby Sealers Inc. [Cl. 270-68.] A tape dispenser folds back one end of each length of tape to form a nonadherent tab thereon.

Long, Florren E. Automatic foaming unit. U. S. patent 2,899,318. Filed Aug. 31, 1956. 11 claims. Assigned to Continental Can Co., Inc. [Cl. 99-180.] The components of a pastry frosting composition are packaged in a double envelope.

Magnus, Finn H. Display stand. U. S. patent 2,899,078. Filed Dec. 3, 1954. 3 claims. [Cl. 211-60.] Several modifications of a paperboard display stand for elongated articles such as erasers are described.

Malm, Carl J., and Crane, Carlton L. Manufacture of cellulose acetate. U. S. patent 2,899,423. Filed Aug. 23, 1957. 7 claims. Assigned to Eastman Kodak Co. [Cl. 260-227.]

Marsh, John L. Apparatus and method of bonding paper having thermoplastic coating. U. S. patent 2,898,973. Filed July 28, 1955. 6 claims. Assigned to Kalamazoo Vegetable Parchment Co. [Cl. 154-1.]

Merrell, Allen W. Bag filling mechanism. U. S. patent 2,-898,721. Filed Nov. 23, 1955. 1 claim. Assigned to Sattley Co. [Cl. 53-244.] Wrapped stacks of coins are inserted into a bag.

Mestre, Luis. Offset printing machine and sheet gage. U. S. patent 2,899,202. Filed May 16, 1957. (Divided; original filed Sept. 2, 1953.) 8 claims. Assigned to Lewfor Devt. Corp. [Cl. 271-53.] Improved sheet register means are provided in an offset press.

Moore, George A. Method and apparatus for making container for liquid products. U. S. patent 2,898,822. Filed June 11, 1957. 10 claims. [Cl. 93-51.] A frustopyramidal beverage carton is formed.

Morse, Edward A. Thermoplastic paper. U. S. patent 2,-899,351. Filed Feb. 25, 1957. 6 claims. Assigned to Personal Products Corp. [Cl. 162-146.] The furnish includes fibers of wood, vinyl chloride-acetylonitrile, and a modified vinyl chloride-vinyl acetate polymer.

Nicoli, Vincent J. Bag sealing and printing device. U. S. patent 2,898,717. Filed July 8, 1955. 8 claims. [Cl 53-131.] The device seals a bag mouth with pressure-sensitive tape and imprints indicia on the tape.

Nuessle, Albert C., and McKone, Peter J., Jr. Process of applying dimethylol ethyleneurea, propyleneureas and butyleneureas to cellulose and regenerated cellulose fabrics and mechanically finishing the fabrics. U. S. patent 2,899,263. Filed July 1, 1950. 2 claims. Assigned to Joseph Bancroft & Sons Co. [Cl. 8-116.3.]

Rakus, Alexander B. Process and apparatus for applying a coating to a moving web. U. S. patent 2,899,339. Filed Aug. 23, 1957. 7 claims. Assigned to E. I. du Pont de Nemours and Co. [Cl. 117-102.] The formation of edge beads is prevented.

Reid, Harry A., and Gall, John C. Apparatus for wetting a roll of pre-pasted wallpaper. U. S. patent 2,898,883. Filed July 7, 1954. 4 claims. Assigned to Sears, Roebuck and Co. [Cl. 118-419.]

Rouse, Benjamin P., Jr., and Hill, Roy O., Jr. Stabilizer cellulose ester compositions and process for preparing the same. U. S. patent 2,899,316. Filed Feb. 13, 1957. 15 claims. Assigned to Eastman Kodak Co. [Cl. 106-173.] This is similar to U. S. patent 2,899,315 (Aug. 11, 1959).

Sandison, Alexander G. Device for screening pulp. U. S. patent 2,899,069. Filed April 18, 1957. 6 claims. Assigned to William Kennedy & Sons Ltd. [Cl. 210-405.] The construction permits the stock supply pressure to be used to impart tangential velocity to the stock in a centrifugal stock screen.

Schaefer, Emil M. Partitioned carton. U. S. patent 2,-899,122. Filed June 11, 1956. 8 claims. [Cl. 229-28.] A partitioned tray designed to be filled with bakery goods and then overwrapped is provided

Schubert, Dale L. Method of making crosscut wood flakes and sawmill cross grain flaking planer therefor. U. S. patent 2,898,958. Filed Aug. 16, 1957. 5 claims. Assigned 50% to Industrial Devt. Co. [Cl. 144-172.] A lumber-planing machine for sawmill use produces crosscut wood flakes of use in wood-particle board.

Shields, Albert F. Folding and gluing machine. U. S. patent 2,898,819. Filed May 18, 1955. 11 claims. Assigned to S & S Corrugated Paper Machinery Co., Inc. [Cl. 93-49.] This is similar to U. S. patent 2,898,818 (Aug. 11, 1959).

Shields, Albert F. Folding machine. U. S. patent 2,898,818. Filed Dec. 9, 1954. 11 claims. Assigned to S & S Corrugated Paper Machinery Co., Inc. [Cl. 93-49.] The machine folds heavy corrugated board blanks to form collapsed tubes in the manufacture of corrugated cartons.

Shields, Albert F. Folding machine. U. S. patent 2,898,821. Filed March 21, 1956. 9 claims. Assigned to S & S Corrugated Paper Machinery Co., Inc. [Cl. 93-49.] This is similar to U. S. patent 2,898,818 (Aug. 11, 1959).

Sidebotham, Melvin H., Sr., Sidebotham, Gordon L., and Sidebotham, Melvin H., Jr. Method of and apparatus for winding a sheath around a core. U. S. patent 2,898,824. Filed Jan. 20, 1955. 9 claims. Assigned to Joseph Dixon Crucible Co. [Cl. 93-81.] A paper strip is wrapped about a core to form a pencil.

Stobb, Anton R. Tension control means for a web of paper. U. S. patent 2,899,199. Filed Dec. 16, 1957. 10 claims. [Cl. 271-2.3.]

Stowitts, Frank H., and Wheeler, Donald P. Dispensing carton with a push-pull closure for same. U. S. patent 2,-899,119. Filed June 11, 1956. 8 claims. Assigned to Michigan Carton Co. [Cl. 229-17.]

Sweet, Sterling S., and Van Horn, Maurice H. Cements for bonding high polymer sheets to each other and method of using same. U. S. patent 2,899,348. Filed April 30, 1954. 10 claims. Assigned to Eastman Kodak Co. [Cl. 154-136.] Trifluoroacetic and dichloroacetic acids are used as solvents for cellulose, regenerated cellulose, and cellulose derivatives.

Thompson, John K. Means for dispensing packaging tape from rolls. U. S. patent 2,899,144. Filed March 28, 1957. 5 claims. [Cl. 242-58.4.] A packaging line tape dispenser holds several rolls of tape and automatically transfers from one roll to the next.

Thomsen, Alfred M. Method of making paper pulp. U. S. patent 2,898,994. Filed March 31, 1953. 5 claims. [Cl. 162-24.] A chemical recovery and cooking liquor regeneration process is provided for a method of pulping bagasse.

Thorup, Abraham B. Folding box with partition. U. S. patent 2,899,121. Filed Jan. 23, 1957. 9 claims. Assigned to Central Fibre Products Co., Inc. [Cl. 229-27.] A corrugated paperboard shipper for eggs is provided.

Voorhees, Albert, and Scott, Edward F. Oxidation-ingrain color emulsions. U. S. patent 2,899,261. Filed May 28, 1957. 16 claims. Assigned to American Cyanamid Co. [Cl. 8-62.] Sodium lignosulphonate and carboxymethylcellulose are used in forming a composition for printing or dyeing textiles.

Wadlow, Derek N. Offset lithographic printing machines. U. S. patent 2,898,853. Filed Jan. 29, 1958. 12 claims. Assigned to Rotaprint Ltd. [Cl. 101-217.] A diposable blanket and plate combination is formed of paper.

Williams, Robert F., Jr., and Lowe, Carol S. Stabilized cellulose ester compositions and process for preparing the same. U. S. patent 2,899,315. Filed Feb. 13, 1957. 16 claims. Assigned to Eastman Kodak Co. (Cl. 106-171.] Cellulose esters such as cellulose acetate are stabilized against the effect of heat in air.

Willis, Grant N. Machine for packaging lugs. U. S. patent 2,898,718. Filed Feb. 11, 1957. 8 claims. Assigned to Cinch Mfg. Corp. [Cl. 53-196.] The lugs are sealed between strips of tape and the tape is coiled and mounted on a base sheet.

Wilson, John B. Apparatus for heat-sealing metallic liners in containers. U. S. patent 2,898,974. Filed May 28, 1957. 9 claims. Assigned to Reynolds Metals Co. [Cl. 154-1.]

Young, Harland H., Ohlson, John L., and Barshefsy, Gustave. Manufacture of structural board from rumen. U. S. patent 2,899,352. Filed Sept. 24, 1953. 12 claims. Assigned to Swift & Co. [Cl. 162-148.]

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Anderson, Andrew W. Mechanism for heat sealing wrappers and a method of sealing packages. U. S. patent 2,899,791. Filed June 14, 1957. 2 claims. Assigned to Scandia Pkg.

Machinery Co. (Cl. 53-376.] The machine heat-seals a wrapper about a package having flexible walls.

Auer, Frederick G. Stripper mechanism. U. S. patent 2,899,871. Filed Aug. 28, 1953. 8 claims. Assigned to Champlain Co., Inc. [Cl. 93-36.] A machine for die-cutting paperboard sheets to form paperboard milk cartons or the like is provided with improved means for stripping the waste from the sheets.

Cahoon, Nelson C., and Korver, Margaret P. Barrier films for galvanic cells. U. S. patent 2,900,433. Filed April 18, 1955. 4 claims. Assigned to Union Carbide Corp. [Cl. 136-146.] The film is of methylcellulose.

Cavanaugh, Edward F., and Keil, Havard L. Modified animal glue and method of preparation. U. S. patent 2,900,267. Filed Oct. 17, 1956. 20 claims. Assigned to Armour and Co. [Cl. 106-135.] The glue is for use in sealing cartons or making gummed paper or the like.

Cleveland, Eric G., and Standley, Archibald D., Jr. Method and apparatus for counting and packaging articles. U. S. patent 2,899,784. Filed Jan. 6, 1956. 11 claims. Assigned to Delta Eng. Corp. [Cl. 53-61.] A packaging machine is provided with photoelectric means for counting the articles into groups of accurate number in preparation for cartoning or the like.

Dreisbach, Robert R., and Lang, John L. Process for making fire retardant cellulosic articles. U. S. patent 2,900,279. Filed Oct. 1, 1954. 4 claims. Assigned to The Dow Chemical Co. [Cl. 117-136.] The article is immersed in a solution of the reaction product of ethylenediamine with phosphoric or boric acid and the reaction product is insolubilized with an organic acid.

Drnec, Harry F., Snyder, Leonard W., and Johnson, Richard H. Heavy duty paperboard container. U. S. patent 2,900,123. Filed June 12, 1957. 5 claims. Assigned to Container Corp. of America. [Cl. 229-45.] A paperboard beer case is described.

Durant, John H. Slab-rossing machine. U. S. patent 2,-899,993. Filed June 25, 1956. 4 claims. Assigned to Lloyd J. Ruble. [Cl. 144-208.] The machine provided bark slabs in preparation for chipping and pulping operations.

Farkas, Alfred J. Indexing means for package printing mechanisms. U. S. patent 2,899,890. Filed Sept. 19, 1955. 1 claim. [Cl. 101-35.]

French, Lionel J. B. R. Bookbinding machines. U. S. patent 2,900,093. Filed Feb. 27, 1957. 2 claims. [Cl. 214-7.] The delivery end of the machine is provided with suitable conveying and stacking means.

Gebhardt, Otto. Apparatus for and method of clamping the ends of bags for hams, sausages or the like. U. S. patent 2,-899,785. Filed March 23, 1954. 3 claims. [Cl. 53-124.] The open end of a bag filled with a ham or the like is inserted through an eyelet and the eyelet clamped to seal the bag.

Gross, Florence A. Egg carton. U. S. patent 2,900,119. Filed May 26, 1958. 7 claims. [Cl. 229-2.5.] A molded pulp egg carton is provided in which the eggs are supported in two layers, one dozen eggs in each layer.

Harker, Charles B. Bag opening mechanism for packaging machine. U. S. patent 2,899,786. Filed Sept. 6, 1957. 14 claims. Assigned to Bartelt Eng. Co. [Cl. 53-187.]

Holcroft, Donald E. Silencer. U. S. patent 2,900,024. Filed Oct. 7, 1955. 16 claims. Assigned to Scott Paper Co. [Cl. 162-371.] Suction roll noise is reduced by a comblike device attached to the leaving edge of the suction box of the roll.

Hoopes, Harry P., and Riensenberg, William P. Method for preheating cementitious insulating material. U. S. patent 2,900,109. Filed April 29, 1957. 3 claims. Assigned to Fibreboard Paper Products Corp. [Cl. 222-1.] An asbestos-cement slurry is preheated before forming.

Hornbostel, Lloyd. Table roll and deflector suction device. U. S. patent 2,900,023. Filed April 10, 1956. 6 claims. Assigned to Beloit Iron Works. [Cl. 162-352.]

Key, Edward M. Apparatus for making wood pulp chips. U. S. patent 2,899,992. Filed Sept. 23, 1957. 3 claims. Assigned 50% to Herbert B. Fischborn. [Cl. 144-162.] The apparatus is designed to be positioned ahead of a planer in a sawmill processing line.

La Bombard, Leon E. Folding and gluing apparatus. U. S. patent 2,899,873. Filed July 23, 1956. 11 claims. Assigned to International Paper Box Machine Co. [Cl. 93-52.] The glue flaps of box blanks are registered with the glue-applying means.

Labombarde, Raymond A. Flap folding apparatus and method. U. S. patent 2,899,872. Filed May 8, 1956. 20 claims. [Cl. 93-49.] All the leading flaps of flat box blanks are overfolded while the blanks are advanced at high speed in untimed relation along a path.

Lamb, George E. Tail slitter. U. S. patent 2,900,025. Filed June 25, 1956. 6 claims. Assigned to Lamb-Grays Harbor Co., Inc. [Cl. 164-75.]

Lauring Edgar A. Drill removing means for multiple spindle drill. U. S. patent 2,900,184. Filed Dec. 27, 1957. 3 claims. Assigned to Minnesota and Ontario Paper Co. [Cl. 269-127.] The drill is for forming holes in acoustical board.

Leibold, Eldon L. Apparatus for edge-gluing, cutting, and stacking carbon paper from roll carbon stock. U. S. patent 2,899,926. Filed Aug. 9, 1957. 18 claims. [Cl. 118-41.]

Leone, Salvatore J. Carton with top handle. U. S. patent 2,900,124. Filed April 11, 1958. 9 claims. Assigned to The New Haven Board and Carton Co. [Cl. 229-52.]

McIntyre, Sidney S., Sr. Log yarding and loading apparatus. U. S. patent 2,900,089. Filed Jan. 3, 1956. (Divided; original filed July 2, 1951.) 2 claims. Assigned to Humboldt Co. [Cl. 212-59.]

Normandin, William O. Manufacture of gusset type envelopes. U. S. patent 2,899,874. Filed April 28, 1958. 28 claims. [Cl. 93-62.]

O'Connell, Richard A. Production of non-woven fabrics. U. S. patent 2,900,291. Filed March 18, 1957. 3 claims. Assigned to U. S. Secretary of Agr. [Cl. 154-101.] A method of effecting point-of-contact interfiber bonding is described.

Oshima, Motoyoshi, Kusama, Jun, and Ishii, Tadao. Process for saccharification of cellulose-containing material. U. S. patent 2,900,284. Filed Sept. 30, 1955. 3 claims. [Cl. 127-37.]

Otto, Stuart. Electromagnetic packaging apparatus. U. S. patent 2,899,783. Filed July 5, 1955. 23 claims. [Cl. 53-59.] A machine for cartoning nails or the like is provided with electromagnetic means for orienting all the nails in one direction prior to the cartoning.

Sandison, Alexander G. Device for screening pulp. U. S. patent 2,900,007. Filed March 26, 1957. 4 claims. Assigned Kennedy & Sons Ltd. [Cl. 209-300.] A centrifugal screen is provided with an improved impeller and means for cleaning the screen.

Schwebel, Adolf. Sheet feeder for printing and other sheet handling machines. U. S. patent 2,900,186. Filed May 23, 1956. 17 claims. Assigned to MABEG Maschinenbau G.m.b.H. [Cl. 271-62.]

Shaver, Kenneth J. Method of increasing fluidity of aqueous industrial mineral slurries. U. S. patent 2,900,266. Filed Feb. 18, 1957. 19 claims. Assigned to Monsanto Chemical Co. [Cl. 106-100.] An alkali metal polyphosphatosulphate is added to a slurry such as a paper-coating composition.

Smith, Charles C. Machine for packaging fluent material. U. S. patent 2,899,789. Filed Aug. 5, 1854. 10 claims. [Cl. 53-281.] The machine fills a cylindrical paperboard tube with ice cream and closes the ends of the tube with disk caps.

Steiner, Donald Z. Carton. U. S. patent 2,900,122. Filed Nov. 4, 1957. 3 claims. [Cl. 229-39.] A frozen food carton is provided with improved automatic locking means for the cover tuck flap.

Styers, Henry H. Litter bag and hanger therefor. U. S. patent 2,900,156. Filed Oct. 4, 1956. 2 claims. [Cl. 248-99.] A litter bag for use in autos has a top closure permitting attachment of the bag to a door bracket or the like.

Subart, William, Vidas, Charles, and McNamara, John D. Jordan. U. S. patent 2,900,141. Filed May 21, 1956. 11 claims. Assigned to Charles Vidas. [Cl. 241-155.] The jordan includes two pulp-treating stages, one concentric with the other.

Vesak, Joseph. Carrier carton. U. S. patent 2,900,106. Filed March 15, 1956. 2 claims. Assigned to Crown Zellerbach Can. Ltd. [Cl. 220-105.] A totally enclosed collapsible partitioned bottle carrier is provided with a handle element which is withdrawn from a slot in the top of the carton for use.

Vines, Oscar L. Cellular carton. U. S. patent 2,900,121. Filed July 5, 1955. 3 claims. Assigned to Continental Paper Co. [Cl. 229-28.] A single rectangular paperboard blank sets up to form a cellular carton having three rows of cells with three or more cells per row.

Wichman, Merle A. Divider and divided tray. U. S. patent 2,900,120. Filed July 18, 1956. 1 claim. Assigned to American Can Co. [Cl. 229-15.] A flat open-top traylike carton is provided with an interior element which divides the tray into three compartments.

Woodward, Hobart. Walls. U. S. patent 2,899,716. Filed June 29, 1956. 12 claims. Assigned to Minnesota and Ontario Paper Co. [Cl. 20-4.] Fiberboard for wall sheating is prepared to provide channels for the escape of vapor from the wall.

Yeadon, Donald J., Hooker, Leland W., and Garland, Hereford. Apparatus for stripping bark. U. S. patent 2,899,994. Filed May 6, 1957. 15 claims. Assigned to Board of Control of the Michigan Coll. of Mining and Technol. [Cl. 144-208.] A barking machine is provided with elements which act with the bark slitting knives to strip the slit bark from the log.

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Anness, Russell W. Container packaging device. U. S. patent 2,900,776. Filed April 17, 1958. 20 claims. Assigned to Diamond Gardner Corp. [Cl. 53-191.] The machine seals

a blank about several glasses or jars so as to form a unitized merchandising pack.

Arlt, Herbert G., Jr. Sizing compositions containing fatty acid. U. S. patent 2,901,371. Filed June 12, 1957. 5 claims. Assigned to American Cyanamid Co. [Cl. 106-243.] A self-emulsifying paper size comprises a blend of a ketene dimer with a higher fatty acid.

Baldwin, Ann. Knock-down garment form and support therefor. U. S. patent 2,901,154. Filed April 1, 1957. 4 claims. [Cl. 223-68.]

Barnes, James F., and Silversher, Herman I. Tube coating apparatus. U. S. patent 2,900,881. Filed March 23, 1956. 5 claims. Assigned to Foil Process Corp. [Cl. 93-80.] Paraffin wax or the like is applied to the inside of a spiral-wound paper tube through the body of the mandrel on which the tube is wound.

Belk, Wilber C., and Grotewold, Hans W. Box handling device. U. S. patent 2,901,136. Filed Aug. 17, 1956. 7 claims. Assigned to Food Machinery and Chemical Corp. [Cl. 214-314.] The device empties boxes carrying produce.

Bode, Hans. Wall surfacing and method of making the same. U. S. patent 2,901,377. Filed Aug. 11, 1954. 8 claims. Assigned to M. Belmont Ver Standig, Inc. [Cl. 117-70.] Various cellulose esters and ethers are used in compounding a wall-coating composition.

Boomer, Daryl R., Clapperton, Edward T., and Phillips, Russell C. Continuous process for conversion of lignocellulose materials. U. S. patent 2,901,339. Filed Dec. 27, 1955. 5 claims. Assigned to Wooduse, Inc. [Cl. 71-23.] Sawdust or other suitable materials are converted into ligninlike products of use as an agricultural nutrient carrier and soil conditioning agent.

Booth, Max H. Irreversibly elongatable cellulose triacetate structure and method of making. U. S. patent 2,900,669. Filed March 27, 1957. 7 claims. Assigned to E. I. du Pont de Nemours and Co. [Cl. 18-48.]

Britton, William J. Tab-forming device. U. S. patent 2,-901,248. Filed Jan. 18, 1956. 3 claims. Assigned to Johnson & Johnson. [Cl. 270-68.] A tape dispenser folds over one end of each piece of tape dispensed to form a tab for use in removing the length of tape from any surface to which it is applied.

Brunner, Sam W. Display for book protectors. U. S. patent 2,901,103. Filed July 30, 1958. 2 claims. [Cl. 206-80.] A display device formed of heavy paper is provided for use in merchandising plastic book covers.

Burke, John T., Jr. Corrosion reduction. U. S. patent 2,901,439. Filed Oct. 3, 1956. 6 claims. Assigned to National Aluminate Corp. [Cl. 252-389.] Lignosulphonate derivatives are used to prevent corrosion of processing equipment by nitrogenous fertilizer solutions.

Butcosk, Arthur F. Railroad rolling stock cleaners. U. S. patent 2,901,434. Filed Jan. 10, 1957. 4 claims. [Cl. 252-136.] Carboxymethylcellulose is used in a cleaner for railroad car bodies.

Carlson, Carl A., Pommer, Dennis L., and Reiten, Lyndon H. Bottle handling machine. U. S. patent 2,900,775. Filed Jan. 21, 1954. 12 claims. Assigned to General Tool & Eng. Inc. [Cl. 53-160.] The machine cases bottles, cans, or the like.

Carpino, Frank. Box blank. U. S. patent 2,901,158. Filed June 14, 1956. 4 claims. [Cl. 229-35.] A lined frozen food box is designed to prevent the corner-locking assembly from interfering with the carton liner.

Chidsey, Francis A., Jr., and Walter, Joseph H. Machine for loading cans into cartons. U. S. patent 2,900,772. Filed Dec. 28, 1956. 4 claims. Assigned to Container Corp. of America. [Cl. 53-48.]

Conklin, Joseph E., and Holmes, Robert J. Inorganic papers and methods of making same. U. S. patent 2,901,390. Filed Dec. 19, 1955. 14 claims. Assigned to General Aniline & Film Corp. [Cl. 162-152.] N-vinyl-2-pyrrolidone is incorporated into a glass fiber slurry and the slurry is sheeted.

Dexter, Robert G., and Willett, John A. Collating machine. U. S. patent 2,901,249. Filed Feb. 1, 1956. 15 claims. Assigned to Cummington Corp. [Cl. 271-26.] The machineis provided with improved sheet separating and feeding means.

Eaton, John C. Chain-type debarking flails cushioned by rubber plates coaxially mounted on a rotor shaft. U. S. patent 2,901,011. Filed April 24, 1956. 2 claims. [Cl. 144-208.]

Engleson, Harry E., and Sramek, Elmer D. Carton expanding and conveyer loading mechanism. U. S. patent 2,900,880. Filed Aug. 30, 1956. 9 claims. Assigned to F. B. Redington Co. [Cl. 93-53.]

Epstein, Jack A. Packaged beverage products and methods of making them. U. S. patent 2,901,357. Filed Sept. 10, 1958. 1 claim. [Cl. 99-171.] A powder for use in making a beverage is packaged within a spiral-wound paper drinking straw.

Gade, Marvin F. Apparatus for controlling stock level in a pressurized headbox. U. S. patent 2,901,040. Filed May 20, 1957. 9 claims. Assigned to Kimberly-Clark Corp. [Cl. 162-259.]

Hartbauer, Ellsworth A. Tucking mechanism for packaging machine. U. S. patent 2,900,778. Filed Aug. 27, 1957. 6 claims. Assigned to F. B. Redington Co. [Cl. 53-376.] The mechanism closes the end panels and tuck flaps of cartons being advanced along a conveyor.

Harwood, Kenneth J. Cellulosic product. U. S. patent 2,900,980. Filed Sept. 30, 1954. 18 claims. Assigned to Kimberly-Clark Corp. [Cl. 128-290.] The wrapper for a catamenial napkin is formed of crosslaid nonwoven threads adhesively bonded at their points of contact.

Haydu, Bartley A. Disposable child's bib. U. S. patent 2,900,640. Filed May 6, 1957. 5 claims. [Cl. 2-49.] The bib is of paper and includes integral neck-encircling elements.

Henchert, John. Container closure and method of forming same. U. S. patent 2,901,161. Filed Dec. 27, 1955. 4 claims. Assigned to Continental Can Co., Inc. [Cl. 229-43.] Improvements are made in the closure of a frustoconical paperboard container having a metal cover disk.

Henriksen, Arthur L. Machine for packing bags with powdered or granulated material. U. S. patent 2,900,774. Filed Dec. 23, 1957. 16 claims. Assigned to Norsk Hydro-Elektrisk Kvaelstofaktieselskab. [Cl. 53-126.]

Hoppe, William, and Kramer, Jacob. Wrapping machine folding channel side wall and conveyor mounting means. U. S. patent 2,900,777. Filed Feb. 28, 1957. 5 claims. Assigned to Package Machinery Co. [Cl. 53-223.] The construction permits easy access for cleaning of the machine.

Hossain, Shafi U. Pulping process. U. S. patent 2,901,389. Filed June 10, 1957. 7 claims. Assigned to Abitibi Power & Paper Co., Ltd. [Cl. 162-72.] Dimethyl sulfoxide is employed as a pulping agent for wood chips.

Kent, Eugene A., and Sacco, Louis J., Jr. Antistripping agents for bituminous materials. U. S. patent 2,901,370. Filed July 22, 1957. 2 claims. Assigned to National Aluminate Corp. [Cl. 106-123.] A derivative of tall oil fatty acids is used in compounding a road construction composition.

Koch, Melvin B. Automatic carton packing machine. U. S. patent 2,900,773. Filed July 18, 1956. 12 claims. Assigned to Animal Trap Co. of America. [Cl. 53-62.] The machine groups small cartons and loads them into cases.

Lehman, Roland J. Web coating process and shielding apparatus to prevent beaded edges. U. S. patent 2,901,376. Filed Feb. 27, 1957. 8 claims. Assigned to E. I. du Pont de Nemours and Co. [Cl. 117-44.] A paper web is coated without leaving beaded edges at the margin of the coating.

Martin, George M. Automatic sheet stacker apparatus. U. S. patent 2,901,250. Filed April 1, 1957. 22 claims. [Cl. 271-68.] The delivery end of a printer-slotter producing box blanks is provided with a layboy working in cooperation with a stacking device.

Nystrand, Ernst D. Web winding mandrel. U. S. patent 2,901,192. Filed May 12, 1955. 12 claims. Assigned to Paper Converting Machine Co., Inc. [Cl. 242-75.5] The rotational speed of the mandrel is decreased as the web is wound thereon by the tension applied by the web itself, even though the web may be lightweight, such as toilet tissue.

Offen, Bernard. Apparatus for drying printed webs. U. S. patent 2,900,738. Filed Aug. 22, 1956. 8 claims. [Cl. 34-60.] Heated air is directed on the printed surface; the opposite surface is subjected to the action of steam.

Phelps, Richard W. Paper machinery. U. S. patent 2,901,-191. Filed May 6, 1957. 6 claims. Assigned to Black-Clawson Co. [Cl. 242-66.] Improved web winding machinery is provided.

Richter, Ole J. Device for feeding comminuted cellulosic fibrous material into a pressure vessel. U. S. patent 2,901,149. Filed March 7, 1958. 3 claims. Assigned to Aktiebolaget Kamyr. [Cl. 222-367.]

Russell, John K., and Byrd, Gerald J. Drilling fluids. U. S. patent 2,901,429. Filed April 17, 1956. 5 claims. Assigned to Lignosol Chemicals Ltd. [Cl. 252-8.5.] The composition comprises bentonite, spent sulfite, liquor, and sodium, calcium, or magnesium hydroxide.

Salmonson, Sven A. Apparatus for preconditioning chips in a digester. U. S. patent 2,901,039. Filed Dec. 20, 1954. 3 claims. [Cl. 162-246.]

Shuster, Joseph. Carton feeder. U. S. patent 2,901,086. Filed May 1, 1958. 10 claims. Assigned to General Foods Corp. [Cl. 198-30.] Frozen food cartons are aligned and grouped preparatory to casing the cartons.

Spring, Samuel. Cleaning composition. U. S. patent 2,-901,433. Filed July 17, 1953. 12 claims. Assigned to Pennsalt Chemicals Corp. [Cl. 252-118.] Tall oil is used in a cleanser for railroad car bodies.

Supper, Henry L. Calendar device. U. S. patent 2,900,-749. Filed Feb. 1, 1957. 2 claims. [Cl. 40-114.]

Talbot, Clairborne E., Jr. Container construction. U. S. patent 2,901,159. Filed Sept. 16, 1955. 2 claims. [Cl. 229-39.] A paperboard ice chest is provided for use in cooling beverages.

Tamarin, Bernard J. Container. U. S. patent 2,901,097. Filed June 19, 1958. 8 claims. [Cl. 206-41.2.] A slide opener device is provided in the top panel of a paperboard cigarette box.

Vallas, Charles L. Spiral container tube. U. S. patent 2,901,162. Filed July 18, 1955. 2 claims. Assigned to Cleveland Container Co. [Cl. 229-51.] Improved opening means are provided in a combination can for use in packaging ready-to-cook bakery products.

Vineberg, Joseph H. Package structure. U. S. patent 2,901,160. Filed April 26, 1957. 2 claims. [Cl. 229-40.] A flat suit box is set up from a blank comprising a lightweight paper sheet to which are attached several paperboard panels, a handle, and a tie tape.

Vines, Oscar L. Berry tray. U. S. patent 2,901,156. Filed Oct. 21, 1958. 5 claims. Assigned to Continental Paper Co. [Cl. 229-16.] The bottom-forming portion of the tray is suspended in curved configuration from two opposite side walls.

Vines, Oscar L. Carton. U. S. patent 2,901,155. Filed Dec. 21, 1955. 7 claims. Assigned to Continental Paper Co. [Cl. 229-16.] An open-top tapered-wall one-piece paperboard container for produce is described.

Wagner, Walter W. Sheet turning means. U. S. patent 2,901,246. Filed April 17, 1957. 9 claims. Assigned to International Business Machines Corp. [Cl. 271-3.] A printing machine or the like is provided with means which turns over each sheet as the sheet is moved along the feedway of the machine.

Williamson, Marshall I. Multicellular carriers. U. S. patent 2,901,157. Filed July 19, 1957. 6 claims. Assigned to Federal Paper Board Co., Inc. [Cl. 229-28.] The two rows of cells in a six-pack bottle carrier separate when the carrier is lifted to prevent the bottle tops from scratching the hand of the user.

Wilson, Lucius H., and Jen, Yun. Modified urea-formaldehyde resins and paper containing the same. U. S. patent 2,901,391. Filed June 15, 1954. 17 claims. Assigned to American Cyanamid Co. [Cl. 162-167.] The wet-strength resin is modified with a quaternary ammonium compound.

Zimmerli, Kurt. Calender apparatus. U. S. patent 2,900,747. Filed Nov. 17, 1958. 2 claims. Assigned to B. F. Perkins & Son, Inc. [Cl. 38-52.] Means are provided to drive the driven roll when it is not in engagement with the drive roll.

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Arguillere, Jean E. Apparatus for defibrating hard wood. U. S. patent 2,902,090. Filed July 25, 1956. 4 claims. [Cl. 62-236.]

Beste, Lawrence F. Cellulose triacetate composition. U. S. patent 2,902,383. Filed Sept. 25, 1957. 10 claims. Assigned to E. I. du Pont de Nemours and Co. [Cl. 106-189.] A fluorinated alcohol such as tetrafluoropropanol is used as the solvent.

Bletzinger, John C., and Day, Winterton U. Sanitary napkin. U. S. patent 2,902,038. Filed Feb. 14, 1956. 4 claims. Assigned to Kimberly-Clark Corp. [Cl. 128-290.] This is similar to U. S. patent 2,902,037 (Sept. 1, 1959).

Bradshaw, Robert S. Pneumatic controlled sheet feeder. U. S. patent 2,902,278. Filed Dec. 30, 1957. 19 claims. Assigned to Burroughs Corp. [Cl. 271-30.]

Breton, Paul. Supporting pallet as associated with a cardboard box. U. S. patent 2,902,199. Filed Aug. 1, 1955. 1 claim. Assigned to Société Anonyme de la Papeterie de Chateauneuf-la-Foret. [Cl. 229-14.]

Burkhard, Charles A. Resinous materials plasticized with a methoxybenzene dicarboxylic acid ester. U. S. patent 2,902,382. Filed April 13, 1956. 10 claims. Assigned to General Electric Co. [Cl. 106-181.] The plasticizers provided may be used in compositions of cellulose esters and ethers.

Buttery, Kenneth T. Container. U. S. patent 2,902,203. Filed July 31, 1957. 3 claims. Assigned to Sutherland Paper Co. [Cl. 229-31.] A traylike carton is formed so that there are no openings in the panels or seams of the completed box.

Connolly, Francis A. Glue head for corrugated board box folding machine. U. S. patent 2,902,00. Filed Jan. 10, 1957. 4 claims. Assigned to S & S Corrugated Paper Machinery Co., Inc. [Cl. 118-200.]

Daul, George C., Wise, Harold F., and Wharton, John. Process for improving the properties of regenerated cellulose fibrous material wherein said material is treated while still in the gel state. U. S. patent 2,902,391. Filed Jan. 23, 1957. 11 claims. Assigned to Courtaulds, Inc. [Cl. 117-145.] An aminoplast or other suitable resin is incorporated in the fibers while they are in the gel state.

Dornauf, Arnold. Exchangeable filter element for high differential pressures. U. S. patent 2,902,164. Filed Nov. 3, 1955. 1 claim. Assigned to Faudi Feinbau G.m.b.H. [Cl. 210-486.] The filter involves use of two superposed resin-impregnated paperboard disks, ribbed and secured together at the points where the ribs contact each other.

Engblom, Douglas R. Slide top dispenser carton for cigarettes and other articles. U. S. patent 2,902,201. Filed March 24, 1958. 16 claims. Assigned 50% to Hubert J. Brown. [Cl. 229-17.]

Enos, Joseph, Jr. Cartons and method of carton formation. U. S. patent 2,901,873. Filed Dec. 31, 1956. 11 claims. Assigned to California Wheeling Machine Prods. Co. [Cl. 53-29.] A heavy-duty paperboard container for bulk shipping of pipe fittings and the like is set up from two paperboard blanks.

Fallert, Clifford D. Heavy-duty container for bulk material with protective liner and releasable lock cover. U. S. patent 2,902,202. Filed Oct. 18, 1956. 3 claims. Assigned to Crown Zellerbach Corp. [Cl. 229-23.]

Forster, Leslie G. Wrapping machine for articles or assemblies of articles. U. S. patent 2,901,874. Filed Dec. 24, 1957. 12 claims. Assigned to Forsters Machine Co. Ltd. [Cl. 53-223.]

Gentry, Curtis A., Jr. Combined log debarker and saw. U. S. patent 2,902,069. Filed April 2, 1957. 3 claims. [Cl. 144-3.] In sawing lumber from logs, slabs and chips are produced in debarked condition, ready for chipping.

Gray, Harry C. Machine having seaming rolls for securing preassembled rings to ends of container side wall. U. S. patent 2,902,075. Filed Feb. 16, 1955. 10 claims. Assigned to Summitt Container Co. [Cl. 153-1.] Metal reinforcing rims are attached to the ends of a cylindrical paperboard ice cream container.

Harwood, Kenneth J., Mayo, Howard A., and Bletzinger, John C. Sanitary napkin. U. S. patent 2,902,037. Filed May 25, 1955. 4 claims. Assigned to Kimberly-Clark Corp. [Cl. 128-290.] A woven netting is provided as a wrapper for the absorbent pad portion of a sanitary napkin.

Hirschy, Harlan W., Rowe, Carl H., and Harwood, Kenneth J. Absorbent wiping sheet. U. S. patent 2,902,395. Filed Sept. 30, 1954. 4 claims. Assigned to Kimberly-Clark Corp. [Cl. 154-46.] The sheet comprises a number of layers of interbonded creped tissue to one face of which is adhesively bonded a nonwoven netting.

Hochfeld, Henry. Process and machine for pleating pliable materials. U. S. patent 2,901,951. Filed April 15, 1958. 18 claims. [Cl. 93-84.] Complex pleats and folds are formed in paper and other materials for use in filters, Chinese lanterns, etc.

House, Arthur W. Portable handle for milk container and like. U. S. patent 2,902,309. Filed April 7, 1958. 2 claims. [Cl. 294-27.] A gable-top paperboard milk carton is provided with a a handled device for use in supporting the carton while pouring from it.

Huehns, Elmer H. Garment cases. U. S. patent 2,902,144. Filed Aug. 31, 1956. 1 claim. [Cl. 206-7.] A shipping case for hangered garments is described.

Jacobsen, Paul W. Web tensioning control system. U. S. patent 2,902,232. Filed May 16, 1955. 2 claims. Assigned to H. G. Weber & Co., Inc. [Cl. 242-75.47.] The system is for use in a roll stand for unwinding a paper roll.

Latimer, James T. Log-debarking apparatus. U. S. patent 2,902,070. Filed April 27, 1956. 1 claim. Assigned to Jackson Industries, Inc. [Cl. 144-208.] The barker handles irregularly shaped logs.

Lutz, Friedrich, and Daniel, Hermann. Pedestal mounted portable bag closing machine. U. S. patent 2,901,992. Filed May 14, 1957. 10 claims. Assigned to Union Special Maschinenfabrik G.m.b.H. [Cl. 112-11.] The apparatus forms stitched closures in paper bags.

Manners, John V. Grape box. U. S. patent 2,902,200. Filed Oct. 2, 1956. 1 claim. Assigned to Paperbox Corp. [Cl. 229-16.] A display box for grapes and the like is formed so that the closure of the box consists of a recessed bottom panel.

Mengis, Albin J. Apparatus for applying pressure sensitive materials. U. S. patent 2,901,999. Filed Feb. 16, 1956. 2 claims. Assigned to Wolf Brothers, Inc. [Cl. 118-1.] Pressure-sensitive adhesive is applied to envelope flaps.

Milne, David T. Coagulation of cellulosic colloids. U. S. patent 2,902,334. Filed Jan. 29, 1953. 11 claims. Assigned to American Viscose Corp. [Cl. 18-54.] Films, filaments, and the like are produced so as to be self-supporting in the wet gel state.

Moore, George A. Container closure. U. S. patent 2,902,204. Filed March 19, 1957. 2 claims. [Cl. 229-37.] Improved top and bottom closures are provided in a paperboard flat-top milk carton.

Page, John E. Container construction. U. S. patent 2,902,198. Filed July 11, 1956. 2 claims. Assigned to Gibson Patent Containers, Ltd. [Cl. 229-5.7.] Improvements are made in a collapsible cylindrical paperboard container for ice cream.

Paquin, Leon J. Filled paper. U. S. patent 2,902,399. Filed Nov. 29, 1955. 1 claim. Assigned to The National Cash Register Co. [Cl. 162-181.] An alumino-silicate filler is precipitated on fibers of paper to be used in a no-carbon-required transfer copy system.

Paton, Joseph H., Sherrill, James W., and Vander Pyl, Chester A., Jr. Method of and machine for forming pleated paper into annular filter elements. U. S. patent 2,901,949. Filed Dec. 28, 1956. 18 claims. Assigned to Fram Corp. [Cl. 93-1.]

Reynolds, Julian L. Laminate for wrapping precooked frozen food. U. S. patent 2,902,396. Filed Aug. 28, 1956. 6 claims. [Cl. 154-50.] This is a laminate of metal foil and paper which has been coated on the exposed surface of the paper with polyethylene.

Ross, Sidney D. Dielectric compositions. U. S. patent 2,902,451. Filed Nov. 2, 1953. 6 claims. Assigned to Sprague Electric Co. [Cl. 252-66.] A capacitor paper comprises paper impregnated with chlorinated naphthalene containing 5–15% liquid polybutadiene-1,3.

Samuelson, Hans O. Process of treating wood pulp. U. S. patent 2,902,481. Filed March 24, 1955. 13 claims. Assigned to Mo och Domsjo AB. [Cl. 260-212.] A pulp purification process involves caustic swelling, treatment with an acid solution of chlorine dioxide, and a caustic cook.

Schappel, Joseph W. Textile material of regenerated cellulose containing a polyacrylamide. U. S. patent 2,901,813. Filed Oct. 20, 1953. 5 claims. Assigned to American Viscose Corp. [Cl. 28-82.] Crush-resistant rayon fibers are obtained from a viscose in which has been incorporated polyacrylamide or certain other polymers of acrylamide.

Schroer, Walter E., Trybinski, Victor, Jr., and Walling, Irvin H. Locking mechanism for binders. U. S. patent 2,902,039. Filed July 16, 1956. 1 claim. Assigned to Loose Leaf Metals Co. [Cl. 129-13.]

Shields, Albert F. Spring feeder for warped board. U. S. patent 2,902,280. Filed Sept. 6, 1957. 8 claims. Assigned to S & S Corrugated Paper Machinery Co. Inc. [Cl. 271-44.]

Smith, Joe L. Shoe display rack. U. S. patent 2,902,167. Filed April 24, 1957. 1 claim. [Cl. 211-34.] A wire frame attaches to a conventional shoebox for displaying one of the shoes from the box.

Spiatto, Frank. Easel card feeding and glue applying machine. U. S. patent 2,902,279. Filed April 30, 1957. 12 claims. [Cl. 271-44.]

Taylor, William H. Apparatus for feeding, counting and stacking magazines, books and other articles. U. S. patent 2,901,952. Filed Dec. 16, 1955. 9 claims. [Cl. 93-93.]

Teppema, Jan. Aqueous adhesive comprising acid, phenolaldehyde resin and polymer of vinyl acetate. U. S. patent 2,902,458. Filed Oct. 11, 1954. 2 claims. Assigned to The Borden Co. [Cl. 260-29.3.] The adhesive is for use in bonding paper and other materials.

Teppema, Jan. Aqueous dispersion containing oxidizing acid, phenolaldehyde resin, and polymer of vinyl acetate. U. S. patent 2,902,459. Filed Oct. 20, 1954. 4 claims. Assigned to The Borden Co. [Cl. 260-29.3.] The dispersion is an adhesive for use in bonding wood and other cellulosic materials, plastics, and inorganic materials.

Thumm, Byron A. Method of producing all skin rayon. U. S. patent 2,902,381. Filed July 26, 1957. (Divided; original filed June 29, 1955.) 1 claim. Assigned to American Viscose Corp. [Cl. 106-165.] Monoaminopyridine is used as coagulation modifier.

Wathen, Ernest L. Display device. U. S. patent 2,902,176. Filed Sept. 26, 1958. 5 claims. [Cl. 211-178.] A paperboard display panel is engaged in supporting relation with a tripod-type paperboard base member.

Wilcox, Isaac L., Barnes, Alfred A., Patch, Clarence E., and Spurr, Robert. Apparatus for handling flat end closure blanks for cartons. U. S. patent 2,901,950. Filed Aug. 31, 1954. (Divided; original filed May 8, 1948.) 13 claims. Assigned to Oswego Falls Corp. [Cl. 93-55.1.] The blanks are heat-sealed as closures to flat-top milk cartons.

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Altenburg, William M. Molded pulp pallet. U. S. patent 2,903,218. Filed July 30, 1956. 4 claims. Assigned to Diamond Gardner Corp. [Cl. 248-120.]

Anderau, Emil G. Bag closure. U. S. patent 2,903,287. Filed Sept. 20, 1956. 7 claims. Assigned to Stoffel Seals Corp. [Cl. 292-325.] A binding strap with deformable metal latch is provided to seal the gathered neck of a mail bag.

Arrowsmith, Robert K., and Arrowsmith, Jessie M. Educational device. U. S. patent 2,902,775. Filed March 14, 1955. 9 claims. [Cl. 35-9.] A device for teaching children various subjects includes a number of imprinted paperboard panels hinged together along several lines by ring-binder elements.

Berke, Aaron. Receptacle member. U. S. patent 2,903,178. Filed May 16, 1958. 4 claims. [Cl. 229-34.] A two-piece hexagonal telescoping-cover hat box is provided.

Berlyn, Martin J. Paper making machines. U. S. patent 2,903,061. Filed July 2, 1956. 10 claims. Assigned to Dominion Eng. Works Ltd. [Cl. 162-295.] In a fourdrinier section, the wire is draped in free-running downwardly convex fashion.

Brooke, Harold, and Parker, George J. Wrapping or like machines. U. S. patent 2,903,635. Filed June 25, 1956. 1 claim. Assigned to The Forgrove Machinery Co. Ltd. [Cl. 318-6.] Means are provided to stop the machine in case a break occurs in the supply web of wrapping material.

Brundell, Per G., and Jonsson, K. E. A. Swingable debarking tools and mounting means for such tools of a rotary-ring-type debarker. U. S. patent 2,903,028. Filed Aug. 18, 1958. 9 claims. Assigned to Soderhamns Verkstader AB. [Cl. 144-208.]

Buckman, Kenneth E. Fluid filters. U. S. patent 2,903,136. Filed March 14, 1955. 1 claim. Assigned to General Motors Corp. [Cl. 210-483.] An auto engine oil filter is formed of a stack of pairs of disks, each pair including one aluminum disk and one disk of resin-impregnated paper.

Callen, Wallace I. Photographic album. U. S. patent 2,902,996. Filed March 29, 1957. 2 claims. [Cl. 129-20.] An assembly of paper and plastic form the leaves of a photo album or the like.

Crane, Harold S. Pulp molding die. U. S. patent 2,093,063. Filed May 6, 1958. 4 claims. Assigned to Diamond Gardner Corp. [Cl. 162-411.] The die forms molded pulp articles having intricately formed or curved areas.

Denton, Harvey R. Packaging apparatus and method. U. S. patent 2,902,907. Filed June 18, 1956. 9 claims. Assigned to Diamond Gardner Corp. [Cl. 93-54.] A film cover is heat-sealed over the top of a filled paper tray.

Donahue, John P. Method and apparatus for the production of flockcoated sheet material. U. S. patent 2,903,376. Filed Nov. 5, 1956. 5 claims. Assigned to D. & S. Processing Co., Inc. [Cl. 117-20.]

Durandeaux, Jan. Method and means for neutralizing obnoxious cigarette combustion products. U. S. patent 2,902,998. Filed Oct. 17, 1955. 4 claims. [Cl. 131-9.] Palladium chloride is applied to the inner surface of the cigarette paper.

Eckles, William J. Dispensing apparatus. U. S. patent 2,903,167. Filed Oct. 3, 1957. 3 claims. [Cl. 222-480.] A combination pour-or-sift dispensing device is provided for use in a container for table salt.

Frankenstein, William P. Cartons. U. S. patent 2,903,174. Filed Nov. 14, 1955. 10 claims. [Cl. 229-16.] Several modifications of a berry-basket type box, including a display panel, are described.

Heinrich, Ludwig K. Severing apparatus. U. S. patent 2,903,545. Filed Jan. 28, 1957. 6 claims. Assigned to Celotex Corp. [Cl. 219-19.] A number of tiles pasted on thin tissue paper are severed into individual units.

Heitman, Joseph B. Improved process for bleaching cellulose pulp using chlorate. U. S. patent 2,903,326. Filed Oct. 17, 1956. 7 claims. Assigned to Pennsalt Chemicals Corp. [Cl. 8-105.] In a conventional pulp-bleaching process, degradation of the pulp is prevented by inclusion of sodium chlorate.

Holden, Grenville R., and Schiff, Arthur. Fourdrinier cloth. U. S. patent 2,903,021. Filed Dec. 23, 1955. 12 claims. Assigned to F. C. Huyck & Sons. [Cl. 139-383.] The "wire" is woven in endless form from strands of nylon or other synthetic material.

Holmes, Raynor M. Collapsible carton construction. U. S. patent 2,903,180. Filed July 16, 1957. 6 claims. Assigned to Bloomer Bros. Co. [Cl. 229-51.] An ice cream carton is provided with handle elements and is constructed so that it may be opened and reclosed.

Hopkins, Harvey C. Container and closure. U. S. patent 2,903,173. Filed May 9, 1956. 21 claims. Assigned to King Container Corp. [Cl. 229-5.5.] A board-foil laminate is used to form the end closure of a paperboard carton, including a tear-strip opener device.

Joyce, Richard F. Device for loading paper bags and cartons. U. S. patent 2,903,881. Filed Sept. 26, 1957. 7 claims. [Cl. 53-384.] A device for use in retail stores supports a bag or carton in open position while it is being filled.

Kerr, Ralph W. Paper size and method of preparation. U. S. patent 2,903,391. Filed Oct. 9, 1957. 3 claims. Assigned to Corn Prods. Co. [Cl. 162-175.] Pulp is sized with a starch ether which has been gelatinized and dried in contact with borax.

Kress, Bernard H. Process for the dimensional control of cellulosic materials. U. S. patent 2,903,328. Filed Dec. 19, 1956. 6 claims. Assigned to Quaker Chem. Prods. Corp. [Cl. 8-116.] Paper and other materials are treated with acetal condensates such as a reaction product of ethylene oxide with formaldehyde.

Lachiche, Julien, and Oriol, Andre. Method of producing an oriented reinforced artificial sponge. U. S. patent 2,902,720. Filed March 27, 1957. 1 claim. Assigned to Novacel. [Cl. 18-48.] The sponge is formed of fiber-reinforced regenerated cellulose.

Lambert, Harry E. Pulp-molding dies. U. S. patent 2,903,062. Filed Sept. 16, 1955. 7 claims. Assigned to Central Fibre Prods. Co. [Cl. 162-411.] The dies are for molding large egg flats.

McDougall, Alexander E., and McDougall, Victor R. Reel cones for printing paper. U. S. patent 2,903,200. Filed Oct. 18, 1955. 3 claims. [Cl. 242-68.2.] The cones are expandable, so that they may be easily slipped into the reel core, then expanded to engage the core.

McGihon, Leonard. Straight line caser and method. U. S. patent 2,902,810. Filed Sept. 27, 1957. 3 claims. Assigned to King Sales & Eng. Co. [Cl. 53-374.] In a packaging line for casing cans or bottles, the flaps of the case are closed while the case is moved along a linear path.

Maxey, Hillis I., Steinert, Orville G., and Clougherty, Regis J. Packaging machines. U. S. patent 2,902,812. Filed Feb. 10, 1958. 12 claims. Assigned to Pillsbury Co. [Cl. 53-385.] A bag-filling machine is provided with bag-conveying means.

Meloy, Norman F. Adjustable heel for use with log tongs and dipper stick. U. S. patent 2,903,146. Filed June 18, 1957. 5 claims. [Cl. 214-147.]

Molins, Desmond W. Manufacture of composite mouthpieces for cigarettes. U. S. patent 2,902,807. Filed May 29, 1956. 1 claim. Assigned to Molins Machine Co. Ltd. [Cl. 53-177.]

Moyer, Hallard C. Paraffin wax composition of improved gloss stability. U. S. patent 2,903,408. Filed Aug. 29, 1955. 3 claims. Assigned to Sinclair Refining Co. [Cl. 208-21.] The composition is for use in paper coating.

Nichols, Gordon E. Easel-type mount. U. S. patent 2,902,785. Filed Sept. 13, 1957. 8 claims. Assigned to Winthrop-Atkins Co. Inc. [Cl. 40-120.] The mount is for supporting calendar and memo pads.

Paul, Walter. Tube manufacturing machines. U. S. patent 2,902,906. Filed Oct. 31, 1955. 4 claims. Assigned to Windmöller & Holscher. [Cl. 93-19.] Means are provided to register several paper webs which are superposed prior to formation of the assembly into a tube.

Peimer, Stanley. Folding box. U. S. patent 2,903,175. Filed Nov. 21, 1957. 5 claims. [Cl. 229-17.] A cereal box or the like is provided with an integral slide closure means for opening and closing a dispensing opening.

Petrea, James C. Bag closer and sealer. U. S. patent 2,902,805. Filed March 6, 1958. 11 claims. Assigned to Sperry Rand Corp. [Cl. 53-126.]

Reynolds, Walter J. Gross weighing head for produce bagging machine. U. S. patent 2,903,216. Filed Feb. 4, 1957. 7 claims. Assigned to Lynch Corp. [Cl. 248-101.]

Schachte, John H. Automatic weighing and loading apparatus. U. S. patent 2,903,230. Filed Dec. 21, 1953. 20 claims. [Cl. 249-58.] The apparatus is for use in a bag-filling machine.

Stahmer, Berrhardt. Hinging bag content dispenser. U. S. patent 2,903,161. Filed Nov. 30, 1956. 8 claims. [Cl. 222-81.] A self-supporting device is provided to hold a bag so that its contents may be dispensed by the consumer as desired.

Stewart, Alexander E. Wire draping device for fourdrinier machines. U. S. patent 2,903,060. Filed Jan. 11, 1957. 9 claims. Assigned to Dominion Eng. Works Ltd. [Cl. 162-273.] The system provided permits the wire to be fully draped in a closed loop alongside the machine, then installed with a minimum of down time.

Stremke, William F., Stremke, William F., Jr., and Pazderski, Roman R. Dispensing tray for wrapping sheets. U. S. patent 2,903,261. Filed Aug. 28, 1957. (Divided; original filed June 1, 1954.) 2 claims. [Cl. 271-61.] A device for holding s stack of sheets of wrapping paper is described.

Struble, Glenn E. Carton. U. S. patent 2,903,177. Filed April 24, 1958. 7 claims. Assigned to Diamond Gardner Corp. [Cl. 229-34.] Means are provided for locking a telescoping cover in closed position.

Tamarin, Bernard J., and Tamarin, Richard B. Cigarette package and method of making the same. U. S. patent 2,903,157. Filed June 23, 1953. 3 claims. [Cl. 221-260.] A pull-tab device is provided which opens the pack and partially ejects the end cigarettes.

Vanhoof, John F. Self-contained opener for containers. U. S. patent 2,903,179. Filed April 24, 1957. 2 claims. [Cl. 229-51.] A tear-string device is provided for opening a cylindrical container.

Wade, Worth. Fibrous webs and method for their production. U. S. patent 2,903,387. Filed Dec. 23, 1954. 15 claims. Assigned to American Viscose Corp. [Cl. 154-101.] A low-density fiberous mat of hollow fibers of an elastomer is formed.

Walters, Bruce G. Napkin fastening means. U. S. patent 2,902,734. Filed Aug. 6, 1957. 4 claims. [Cl. 24-7.] A tab formed of paper-backed pressure-sensitive tape is used to secure a paper napkin to the garments of the user.

Whitecar, Alten E. Apparatus for assembling packages. U. S. patent 2,902,806. Filed Jan. 16, 1955. 11 claims. Assigned to Smith, Kline & French Labs. [Cl. 53-157.] Packets containing capsules are assembled in a paperboard frame and each assembly is then inserted in a sleeve to form a complete package.

Wolf, Ralph F. Synthetic rubbers reinforced with siliceous pigments. U. S. patent 2,903,439. Filed Jan. 5, 1956. 10 claims. Assigned to Columbia-Southern Chem. Corp. [Cl. 260-23.7.] Sulfurized tall oil is used.

Zimmermann, Frederick J. Oxidation regulation. U. S. patent 2,903,425. Filed Jan. 24, 1955. 2 claims. [Cl. 210-63.] A method is provided for controlling the oxidation rate in a process for the wet combustion of spent pulping liquors and other wastes.

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Austin, John R. Log handling apparatus. U. S. patent 2,903,803. Filed June 20, 1955. 2 claims. [Cl. 37-117.5.] This is a tractorlike apparatus for lifting and carrying logs in the woods.

Bloomquist, Egner L. Case for cardboard milk cartons and the like. U. S. patent 2,904,211. Filed July 26, 1957. 6 claims. [Cl. 220-19.] The case is of wire and prevents damage to the lower ends of the containers.

Cole, Bernard. Poultry nest bottom. U. S. patent 2,904,003. Filed Feb. 20, 1956. 5 claims. [Cl. 119-45.] A synthetic rubber-bonded nonwoven fabric is used.

Cundall, Lincoln A., and Blaisdell, William H. Sheet feeding and turning apparatus. U. S. patent 2,904,334. 3 claims. Assigned to Eastman Kodak Co. [Cl. 271-65.]

Doerr, Richard L., and Holbrook, Robert L. Method to render cellulose resistant to creasing and wrinkling and the product thereof. U. S. patent 2,904,390. Filed Dec. 9, 1958. 19 claims. Assigned to Olin Mathieson Chem. Corp. [Cl. 8-116.3.] The agent is the reaction product of formaldehyde with a monobasic acid hydrazide.

Emerson, Howard J. Identification of sensitized paper or film defects with magnetic materials. U. S. patent 2,904,174. Filed Jan. 27, 1956. 5 claims. Assigned to Eastman Kodak Co. [Cl. 209-72.] A method of inspecting and sorting photo paper or the like is described.

Fife, Irwin L. Turn guiding apparatus for webs. U. S. patent 2,904,333. Filed March 18, 1957. 6 claims. [Cl. 271-2.6.]

Fridrich, Elmer G. Manufacture of conductive glass paper. U. S. patent 2,904,457. Filed Dec. 10, 1957. 5 claims. Assigned to General Elec. Co. [Cl. 117-229.] The glass fibers are coated with a compound of indium.

Gagarine, Dmitry M. Surface cyanoethylated cellulosic textile and process of making the same with limited quantities of reagents. U. S. patent 2,904,386. Filed March 31, 1955. 24 claims. Assigned to Deering Milliken Research Corp. [Cl. 8-116.2.]

Getaz, James L. Hosiery package. U. S. patent 2,904,171. Filed July 12, 1957. 1 claim. Assigned 75% to United States Trust Co. of N. Y. [Cl. 206-46.] An insert blank is provided for use in packaging men's hose.

Gidwitz, Joseph L., and Westfall, Francis. Hanger bar. U. S. patent 2,904,190. Filed Dec. 29, 1954. 1 claim. Assigned to Lanzit Corrugated Box Co. [Cl. 211-123.] A hanger bar is provided for use in a shipping container for hangered garments.

Gilbert, Harry A. Combination pouring and sifting spout for containers. U. S. patent 2,904,226. Filed June 10, 1957. 10 claims. [Cl. 222-189.]

Gorton, Edward S., and Hayward, Claude E. Bag. U. S. patent 2,904,241. Filed Sept. 3, 1957. 6 claims. Assigned to Bemis Bro. Bag Co. [Cl. 229-62.5.] Improved corner closures are provided in multi-ply pasted valve bags of the type used for packaging portland cement.

Hamilton, Joseph P. Pallet. U. S. patent 2,904,297. Filed July 5, 1957. 8 claims. Assigned to Charles Dreifus, Jr. [Cl. 248-120.] The pallet is assembled from wooden slats interlocked with paperboard runner elements.

Hatfield, Marcus R. Primary galvanic cells. U. S. patent 2,904,615. Filed April 18, 1955. 9 claims. Assigned to Union Carbide Corp. [Cl. 136-146.] Barrier material for the cells is formed on a paper machine from a furnish including fibrous methylcellulose, urea-formaldehyde wet-strength resin, and purified cellulose fibers.

Hennessey, Russell J., and Dunning, Robert M. Pan carton. U. S. patent 2,904,170. Filed June 22, 1955. 2 claims. Assigned to Waldorf Paper Prods. Co. [Cl. 206-46.] A piepan-type container is enclosed in an open-end paperboard sleeve.

Hershey, Harry L. Banding machine. U. S. patent 2,903,831. Filed Dec. 23, 1954. 32 claims. Assigned to W. O. Hickok Mfg. Co. [Cl. 53-198.] The machine folds and glues paper bands about packs of paper sheets.

Hicks, Harold C. Magazine paper roll dispensing device. U. S. patent 2,904,274. Filed Feb. 21, 1955. 1 claim. Assigned to Gustave Miller. [Cl. 242-55.3.] A wall-mounted dispenser for rolls of toilet tissue or the like is designed to hold and store rolls other than the one being dispensed.

Holbrook, Robert L., and Doerr, Richard L. Composition and process for crease- and wrinkleproofing cellulosic textile material. U. S. patent 2,904,387. Filed April 28, 1958. 18 claims. Assigned to Olin Mathieson Chem. Corp. [Cl. 8-116.3.] The reaction product of formaldehyde and adipic acid dihydrazide is used.

Holbrook, Robert L., and Doerr, Richard L. Composition and process for crease- and wrinkleproofing cellulosic textile material. U. S. patent 2,904,388. Filed April 28, 1958. 14 claims. Assigned to Olin Mathieson Chem. Corp. [Cl. 8-116.3.] This is similar to U. S. patent 2,904,387 (Sept. 15, 1959).

Holden, Thomas M. Paperboard armchair. U. S. patent 2,904,105. Filed Oct. 25, 1956. 3 claims. Assigned to Fleming & Sons, Inc. (Cl. 155-191.]

Honsel, C. Bag-producing machine. U. S. patent 2,903,946. Filed July 26, 1955. 1 claim. [Cl. 93-13.] Flat and side-fold two-seam bags are produced in either transverse or longitudinal direction.

Hoopes, Harry P., Weber, Horst L., and Neal, Jesse R., Jr. Method of making calcareous-silicious insulating material. U. S. patent 2,904,444. Filed Nov. 26, 1957. Assigned to Fibreboard Paper Prods. Corp. [Cl. 106-78.]

Jones, Wickliffe. High speed carton closing and sealing apparatus. U. S. patent 2,904,833. Filed Nov. 8, 1957. 17 claims. Assigned to R. A. Jones & Co., Inc. [Cl. 53-375.]

Keating, Jerome V. Cigarette package. U. S. patent 2,904,169. Filed June 14, 1956. 2 claims. [Cl. 206-41.] Stiffening panels are inserted to provide the pack with something of the rigidity of a cigarette box.

McClure, Arthur W. Banding machine. U. S. patent 2,903,830. Filed Nov. 24, 1954. 18 claims. Assigned to W. O. Hickok Mfg. Co. [Cl. 53-198.] This is similar to U. S. patent 2,903,831 (Sept. 15, 1959).

Metzner, Albert W. Strip handling device. U. S. patent 2,904,332. Filed Sept. 15, 1955. 11 claims. Assigned to Standard Register Co. [Cl. 271-2.1.] Carbon strips are separated from manifold paper as the paper issues from a business machine, and the carbons are all wound onto a single roll.

Mitten, Frank P. Shipping and storage container. U. S. patent 2,904,382. Filed May 21, 1956. 8 claims. [Cl. 312-261.] The container includes a number of shelves on which are supported trays carrying the objects packaged.

Montgolf, Earl E., Smith, Robert T., Jr., and Hudson, Doyle R. Tube cutting apparatus with simultaneously adjustable idler and driving rolls. U. S. patent 2,903,934. Filed Sept. 16, 1957. 7 claims. Assigned to Textile Paper Prods., Inc. [Cl. 164-60.] The machine cuts spiral-wound paper cores of large diameter, heavy walls, and long lengths.

Nolan, William J. Continuous pulping process. U. S. patent 2,904,460. Filed July 22, 1953. 3 claims. Assigned to University of Fla. [Cl. 162-25.]

Perry, William H., and Olivier, Louis J. Prewrapped box. U. S. patent 2,904,238. Filed Nov. 29, 1956. 3 claims. Assigned to Cambridge Paper Box Co. [Cl. 229-40.] This is an elongated wrapped box closed by four flaps at each end; improved interlocking of the closure flaps is provided.

Rockey, Kenneth O. Polarized light system for web edge control. U. S. patent 2,904,700. Filed July 5, 1956. 3 claims. Assigned to Gpe Controls, Inc. [Cl. 250-225.]

Schlatter, Carl. Process of producing viscose rayon. U. S. patent 2,904,446. Filed July 2, 1957. (Divided; original Nov. 3, 1954.) 6 claims. Assigned to American Viscose Corp. [Cl. 106-165.] The coagulation modifier is an alkylene oxide adduct of 2-aliphatic substituted imidazolines.

Schubert, Paul. Recovery of copper and ammonia from waste liquors from the manufacture of regenerated cellulose. U. S. patent 2,904,399. Filed Oct. 7, 1955. 1 claim. Assigned to J. P. Bemberg A. G. [Cl. 23-147.]

Silver, Stan M. Metered dispensing container. U. S. reissue patent 24,699. Filed July 29, 1958. 17 claims. [Cl. 222-455.] Measuring and dispensing of granular materials is accomplished by a paperboard insert which is folded and glued within the carton.

Sorg, Adam. Method of making filter paper heat sealable. U. S. patent 2,904,448. Filed Aug. 9, 1956. 4 claims. Assigned to Adam Sorg and Edwin V. Hadley. [Cl. 117-38.] Thermoplastic material is deposited on the base paper in small spaced areas.

Southwell, Edward H., and Emal, Earl A. Easy opening airtight container. U. S. patent 2,904,240. Filed Oct. 14, 1955. 11 claims. Assigned to E. H. Southwell Co. [Cl. 229-51.] An improved closure and tear-string opener is provided in a spiral-wound container for packaging biscuit dough.

Thomas, Robert M., and Wagner, George M. Composition of matter useful in rendering cellulose resistant to creasing and wrinkling. U. S. patent 2,904,389. Filed Dec. 9, 1958. 7 claims. Assigned to Olin Mathieson Chem. Corp. [Cl. 8-116.3.] Storage stability of these compositions is improved by the addition of an oxide, hydroxide, or carbonate of zinc or magnesium.

Washburn, Robert S., and Walker, Charles W. E. Method and apparatus for controlling flow of stock through a slice jet. U. S. patent 2,904,461. Filed Aug. 23, 1957. 12 claims. Assigned to Beloit Iron Works. [Cl. 162-216.] Supplemental streams of stock are introduced into the headbox at appropriate points.

Weisshuhn, Peter. Method and apparatus for manufacturing bags. U. S. patent 2,903,947. Filed June 14, 1956. 4 claims. [Cl. 93-35.] Two-seam paper bags are formed.

Wennberg, Olov C. G. Revolving bark-removing tools simultaneously biased by endless pressure-equalizing band. U. S. patent 2,904,085. Filed June 15, 1956. 3 claims. Assigned to General Eng. Co. A.B. [Cl. 144-208.]

Wilcox, Isaac L. Collapsible rectangular container. U. S. patent 2,904,239. Filed March 30, 1953. 3 claims. [Cl. 229-41.] Flanged-edge end-closure caps are partially secured to the box body and the entire structure collapsed until ready for use.

Zies, C. W. Press for dewatering slurries. U. S. patent 2,903,960. Filed June 27, 1957. 1 claim. Assigned to Intern. Basic Economy Corp. [Cl. 110-148.] The press dewaters pulp slurries of very low consistency.

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Adams, James W. Feed for animals. U. S. patent 2,905,558. Filed April 12, 1956. 10 claims. Assigned to American Can Co. [Cl. 99-2.] Spent sulfite liquor derivatives are used.

Anderson, Andrew W. Article feeding and stacking mechanisms. U. S. patent 2,905,341. Filed Feb. 26, 1957. 2 claims. Assigned to Scandia Pkg. Machinery Co. [Cl. 214-6.] The machine apparently arranges cartons or the like into stacked groups.

Anderson, Andrew W. Mechanism for turning packages. U. S. patent 2,905,295. Filed Oct. 9, 1957. 1 claim. Assigned to Scandia Pkg. Machinery Co. [Cl. 193-43.] A cigarette packaging machine is provided with a device for moving packages from a vertical position to a horizontal position.

Arneson, Edwin L. Article carrier. U. S. patent 2,905,359. Filed July 10, 1951. 2 claims. Assigned to Federal Paper Board Co., Inc. [Cl. 220-113.] A partitioned handled bottle carrier is formed so that the compartments extend the full height of the bottles.

Aust, Paul C. Apparatus for filling powdered or granular materials into containers. U. S. patent 2,905,362. Filed Sept. 17, 1954. 1 claim. Assigned to Food Machinery and Chem. Corp. [Cl. 222-56.] An air-entrainment machine for filling bags is provided.

Bertram, William A. Display. U. S. patent 2,905,313. Filed May 15, 1957. 12 claims. Assigned to Lillian D. Bertram. [Cl. 206-45.31.] A counter display container is formed of paperboard to include a windowed container portion, a display panel located in the plane of the window, and a display stand.

Bertram, William A. Display. U. S. patent 2,905,314. Filed May 15, 1957. 4 claims. Assigned to Lillian D. Bertram. [Cl. 206-45.31.] This is similar to U. S. patent 2,905,313 (Sept. 22, 1959).

Bowerman, Edwin R. Method for the production of conductive patterns and resultant product. U. S. patent 2,905,539. Filed Sept. 9, 1955. 12 claims. Assigned to Sylvania Elec. Prods. Inc. [Cl. 41-43.] An etching process is described for forming a printed circuit on one surface of an insulating laminate.

Brown, Edgar F. Carrier for cartons. U. S. patent 2,905,502. Filed Feb. 29, 1956. 3 claims. [Cl. 294-87.2.] A handled wire frame device grips the tops of four flat-top paperboard milk cartons of quart size.

Burgeni, Alfred A. Method and apparatus for manufacturing an absorbent product. U. S. patent 2,905,568. Filed Aug. 16, 1956. 6 claims. Assigned to Personal Prods. Corp. [Cl. 117-11.] One surface of a fibrous batt is wetted and compressed to form a paperlike layer on that surface.

Burton, John A., Helversen, Frederick D., and Hyde, James B. Supporting and coupling means for supply rolls. U. S. patent 2,905,405. Filed Oct. 10, 1955. 7 claims. Assigned to Crown Zellerbach Corp. [Cl. 242-55.53.] A wall-mounted dispenser for rolled paper towels is provided with improved mounting means for the paper rolls.

Clark, Kenneth C., and Strickland, John F. Fishhook package. U. S. patent 2,094,925. Filed Jan. 3, 1956. 3 claims. [Cl 43-57.5.]

Doll, Gregory W. Spacer for packages. U. S. patent 2,905,315. Filed Jan. 7, 1957. 3 claims. [Cl. 206-46.] Interior packing elements are formed of accordion-folded paperboard.

Dowling, Robert J. Insecticidal compositions. U. S. patent 2,905,587. Filed Sept. 3, 1957. 6 claims. Assigned to U. S. Rubber Co. [Cl. 167-30]. Sodium carboxymethylcellulose is used.

Dunlap, Isaac R. Process for making a unified fibrous web. U. S. patent 2,905,584. Filed May 25, 1955. 9 claims. Assigned to Johnson & Johnson. [Cl. 162-135.] Improved wet tensile strength and abrasion resistance are provided in an elastomer-saturated paper by incorporating in the formed web a resin such as a phenol-formaldehyde.

Feigley, David A., Jr., and Hassel, Lloyd V. Decorative felted fibrous sheet. U. S. patent 2,905,583. Filed May 2, 1955. 25 claims. Assigned to Armstrong Cork Co. [Cl. 162-134.] A decorative paper sheet is produced from a mixture of slurries of fibrous materials saturated with a synthetic rubber.

Forrer, Homer W. Light bulb carton and overwrap therefor. U. S. patent 2,905,316. Filed Sept. 23, 1957. 13 claims. Assigned to Mead-Atlanta Paper Co. [Cl. 206-65.]

Gaston, Jack E. Method of shaping a starch-bound fibrous mass. U. S. patent 2,904,843. Filed Feb. 19, 1957. 4 claims. Assigned to Armstrong Cork Co. [Cl. 18-55.] One surface of an acoustical tile or the like containing a starch binder is steam softened and hardened on a flat surface.

Hubbard, James K., and Koontz, Franklin H. Self-bonded paper. U. S. patent 2,905,585. Filed Sept. 30, 1954. 9 claims. Assigned to E. I. du Pont de Nemours & Co. [Cl. 162-157.] Calcium or magnesium thiocyanate is included in a slurry of synthetic fibers; in paper sheeted therefrom, the fibers are bonded at their points of intersection.

Huff, Floyd C. Fiberboard package for paint. U. S. patent 2,905,371. Filed July 17, 1956. 1 claim. [Cl. 229-34.] Paint cans and roller are packed; the carton converts to a tray for use with the roller.

Kennedy, Absalom M., and Jernigan, John M. Process and apparatus for electrolytically treating black liquor. U. S. patent 2,905,604. Filed Jan, 5, 1956. 10 claims. [Cl. 204-56.] Lignin and an alkaline liquor for re-use in the pulping process are obtained.

Kerr, Charles E. Carton filling apparatus. U. S. patent 2,904,945. Filed May 26, 1955. 7 claims. Assigned to Food Machinery and Chem. Corp. [Cl. 53-124.] An improved filling spout and associated mechanisms are provided in a machine for filling cartons with peas, beans, or the like.

Midnight, Wilbur G. Vertical carton sealer. U. S. patent 2,904,941. Filed April 15, 1957. 16 claims. [Cl. 53-24.] Improved pressure-applying means are provided in a machine for sealing the top and bottom flaps of a slotted carton.

Mihalek, Emery. Machine for vending cartons or other articles. U. S. patent 2,905,360. Filed Feb. 10, 1955. 7 claims. Assigned to Hershey Mfg. Co. [Cl. 221-9.] Non-jamming means are provided for feeding milk cartons through a vending machine.

Myers, Harold L. Display device. U. S. patent 2,905,332. Filed July 10, 1956. 6 claims. [Cl. 211-60.] In an easel-type display stand, the articles to be displayed are mounted by inserting them through apertures in panels extending out from the face of the principal display panel.

Notredame, Prosper P., and de Back, William. Machines for filling cases, cartons or other packages with containers such as cans. U. S. patent 2,904,944. Filed Feb. 18, 1955. 5 claims. Assigned to International Machinery Corp. S. A. [Cl. 53-61.]

Radin, Arthur, Raiken, Mathew R., and Shapiro, Lazarus C. Folding machine. U. S. patent 2,904,789. Filed Dec. 20, 1956. 29 claims. Assigned to Victory Container Corp. [Cl. 1-106.] A machine folds a blank into carton form and holds it while flaps are stitched.

Sandberg, Nels H. Apparatus for impregnating wood chips. U. S. patent 2,905,240. Filed Dec. 10, 1954. 6 claims. Assigned to Waldorf Paper Prods. Co. [Cl. 162-237.] Means are provided to move chips to and through an apparatus which preheats the chips and impregnates them with cooking liquor.

Schmidt, Bertil J. M., and Olsson, Karl G. Plaster composition. U. S. patent 2,905,566. Filed April 4, 1956. 9 claims. Assigned to Casius Corp. Ltd. [Cl. 106-170.] Cellulose derivatives such as methylcellulose are used.

Schur, Milton O. Filter for tobacco smoke. U. S. patent 2,905,184. Filed Aug. 19, 1955. 8 claims. Assigned to Olin Mathieson Chem. Corp. [Cl. 131-238.] The filter is made of crumpled paper.

Seifert, Maurice. Labelling machine. U. S. patent 2,905,-866. Filed April 8, 1955. 2 claims. Assigned to Dumatic Inds., Inc. [Cl. 317-123.] A control is provided for the device which cuts individual labels from the label supply tape.

Shields, Albert F. Cutting and creasing press. U. S. patent 2,905,067. Filed June 15, 1954. 11 claims. Assigned to S & S Corrugated Paper Machinery Co., Inc. [Cl. 93-58.3.] Improved sheet-feeding means are provided in a press for forming carton blanks.

Smith, Richmond W. Cleaning and conditioning device. U. S. patent 2,905,241. Filed July 31, 1956. 2 claims. Assigned to Bird Machine Co. [Cl. 162-279.] A suction box and self-cleaning cover plate are provided for use in a system for cleaning and conditioning a papermaking felt.

Ullström, Thord U., and Fransson, Fritz W. Wrapping machines. U. S. patent 2,904,946. Filed March 14, 1957. 15 claims. [Cl. 53-380.] A machine for wrapping a cylindrical object is provided with means to crimp the paper wrapper about the ends of the object.

Van Vick, Roger J., and Erickson, Lester E. Process and machine for producing cartons. U. S. patent 2,905,065. Filed Jan. 24, 1956. 21 claims. Assigned to Central Fibre Prods. Co. [Cl. 93-37.] The machine forms a partitioned paperboard egg carton.

Willey, Grant S. Process of humidifying hardboard. U. S. patent 2,904,893. Filed July 5, 1956. 1 claim. Assigned to U. S. Gypsum Co. [Cl. 34-23.]

Winkler, Alvin L. Lock flap carton folding and strapping machine. U. S. patent 2,905,066. Filed May 16, 1955. 17 claims. Assigned to Acme Steel Co. [Cl. 93-55.1.] The machine applies end closures to heavy-duty shipping containers for refrigerators or the like.

Zahradnik, George J. Receiving tray for duplicators. U. S. patent 2,905,467. Filed Sept. 16, 1957. 9 claims. Assigned to A. B. Dick Co. [Cl. 271-86.]

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Barker, Alvin. Greeting card or folder. U. S. patent 2,-906,058. Filed Feb. 20, 1958. 2 claims. [Cl. 46-175.] The card makes a noise when opened.

Beauregard, Lawrence G. Hair curler. U. S. patent 2,-906,273. Filed March 15, 1956. 16 claims. Assigned to The Gillette Co. [Cl. 132-7.] The device involves a coiled sheet of paper carrying a suitable neutralizer such as sodium bromate.

Beauregard, Lawrence G. Hair waving device. U. S. patent 2,906,275. Filed Jan. 18, 1957. 13 claims. Assigned to The Gillette Co. [Cl. 132-41.] An end paper for use in cold waving hair comprises a paper sheet carrying a deposit of a neutralizing agent such as sodium bromate.

Bellandi, Ferdinando L. Apparatus for feeding containers and labelling the latter. U. S. patent 2,906,424. Filed Feb. 7, 1958. 11 claims. [Cl. 216-9.]

Blain, Albert. Paper stacking guides. U. S. patent 2,906,-527. Filed Nov. 18, 1955. 15 claims. Assigned to Sperry Rand Corp. [Cl. 270-61.] Continuous stationery from a business machine is formed into a fan-folded stack.

Borrow, Antony, Jefferys, Edward G., and Nixon, Ian S. Metabolic processes. U. S. patent 2,906,673. Filed Feb. 3, 1958. 11 claims. Assigned to Imperial Chem. Inds. Ltd. [Cl. 195-125.] This is a process for producing gibberellic acid.

Borrow, Antony, Jefferys, Edward G., and Nixon, Ian S. Process of producing gibberellic acid by cultivation of *Gibberella fujikuroi*. U. S. patent 2,906,671. Filed Jan. 31, 1958. 10 claims. Assigned to Imperial Chem. Inds. Ltd. [Cl. 195-36.]

Borrow, Antony, Jefferys, Edward G., and Nixon, Ian S. Process of producing gibberellic acid by two stage cultivation of *Gibberella fujikuroi*. U. S. patent 2,906,670. Filed Jan. 31, 1958. 9 claims. Assigned to Imperial Chem. Inds. Ltd. [Cl. 195-36.]

Bracht, Paul. Process for manufacture of containers. U. S. patent 2,906,180. Filed Jan. 10, 1958. 2 claims. [Cl. 93-94.] The process forms a convolutely wound paper container having a stepped-down neck over which fits a friction cap.

Cary, John E., Shafer, Russell E., and Cary, Valerie. Fibre stripping device. U. S. patent 2,906,394. Filed July 26, 1956. (Divided; original Sept. 29, 1953.) 1 claim. [Cl. 198-185.] A decorticating machine is provided with means to move the fibers from the decorticating area to a discharge point.

Cary, John E., Shafer, Russell E., and Cary. Valerie. Self propelled fibre harvesting and decorticating machine. U. S. patent 2,905,974. Filed Sept. 29, 1953. 6 claims. [Cl. 19-12.]

Cooper, James. Loose leaf binder. U. S. patent 2,906,-268. Filed March 1, 1957. 5 claims. Assigned to Hall & McChesney, Inc. [Cl. 129-23.]

Crawley, William P. Yarn and thread-receiving cores. U. S. patent 2,906,473. Filed Feb. 23, 1954. 10 claims. Assigned to American Viscose Corp. [Cl. 242-118.32.] A yarn cone formed of wound paper is coated with a friction-reducing agent.

Dennis, William P. Process for forming composite cellular structures. U. S. patent 2,906,642. Filed Jan. 22, 1957. 5 claims. Assigned to E. I. du Pont de Nemours and Co. [Cl. 117-56.] This is similar to U. S. patent 2,906,643 (Sept. 29, 1959.]

Dennis, William P. Process for forming composite cellular structures. U. S. patent 2,906,643. Filed Jan. 22, 1957.

4 claims. Assigned to E. I. du Pont de Nemours and Co. [Cl. 117-56.] A composite artificial sponge is formed of regenerated cellulose and a polyurethane.

Dorland, Rodger M., and McKinney, James W. High yields bisulfite pulping process. U. S. patent 2,906,659. Filed Oct. 19, 1953. 6 claims. Assigned to Abitibi Power & Paper Co., Ltd. [Cl. 162-83.]

Eagon, Beverly M., and Greminger, George K., Jr. Edible oil emulsions. U. S. patent 2,906,626. Filed July 22, 1957. 7 claims. Assigned to The Dow Chemical Co. [Cl. 99-140.] Hydroxypropylmethylcellulose is used.

Fritzinger, George H. Devices for handling tape. U. S. patent 2,906,426. Filed Aug. 28, 1956. 8 claims. [Cl. 216-30.] A hand-supported and -operated device is provided for applying pressure-sensitive tape to cartons or the like.

Galloway, Robert K. Machine for inserting articles into cartons. U. S. patent 2,936,392. Filed April 30, 1956. 4 claims. Assigned to Food Machinery and Chemical Corp. [Cl. 198-32.] The machine erects cartons, fills each with a pie, and closes the cartons.

Goodman, Peter J. Carton dispenser. U. S. patent 2,906,434. Filed Dec. 19, 1955. 1 claim. [Cl. 221-297.] A machine for filling and closing cartons is provided with a supply hopper and feeding means for the cartons.

Harvey, Wildon T., and Ferris, Seymour W. Wax compositions. U. S. patent 2,906,443. Filed Feb. 4, 1958. 4 claims. Assigned to Sun Oil Co. [Cl. 229-3.1.] The compositions form impact-resistant coatings for paperboard milk cartons.

Hungerford, Gordon P., Yarze, Joseph C. Glass fiber dispersions, sheets, plastic impregnated sheets and methods of forming. U. S. patent 2,906,660. Filed April 17, 1956. 15 claims. Assigned to American Machine & Foundry Co. [Cl. 162-102.] Cellulose ethers and other materials are used in forming glass fibers into an aqueous dispersion for papermaking.

Lehtola, Ray H. Portable debarking apparatus. U. S. patent 2,906,306. Filed Oct. 19, 1956. 3 claims. [Cl. 144-208.]

Levering, Dewey R. Methylol derivatives of rosin and rosin compounds. U. S. patent 2,906,745. Filed Sept. 6, 1956. 8 claims. Assigned to Hercules Powder Co. [Cl. 260-97.] Tall oil and tall oil rosin acids are used.

Loudon, Robert C. Binder for papers, pamphlets, catalogs and similar articles. U. S. patent 2,906,267. Filed May 18, 1954. 3 claims. [Cl. 129-1.]

McWhorter, Henry L., and Montgomery, Elmer M. Feeder for carton and the like material. U. S. patent 2,906,529. Filed Aug. 14, 1956. 11 claims. Assigned to Miehle-Goss-Dexter, Inc. [Cl. 271-44.] A box blank die cutter is provided with improved sheet-feeding means.

Matthews, Merton L. Feeding and stacking method and machine. U. S. patent 2,906,530. Filed Jan. 24, 1957. 34 claims. Assigned to Maxson Automatic Machinery Co. [Cl. 271-88.] Improvements are made in a pile-elevating type sheet feeder or stacker for paper and board sheets.

Mauerhoff, Gair H. Protective disc for phonograph records. U. S. patent 2,906,536. Filed Feb. 1, 1955. 1 claim. [Cl. 274-1.] A disk for use between records on a phonograph is formed of laminated plastic and paper.

Mills, George S., and Haxo, Henry E., Jr. Composition comprising a rubber, lagnin and polyisocyanate and method of preparing same. U. S. patent 2,906,718. Filed April 17, 1956. 18 claims. Assigned to U. S. Rubber Co. [Cl. 260-17.5.]

Moses, Asheleigh S. Process and apparatus for decorticating fiber-producing plants. U. S. patent 2,905,975. Filed May 17, 1949. 13 claims. [Cl. 19-15.]

Nolan, William J. Process for separating pith from fibers. U. S. patent 2,905,973. Filed April 16, 1956. 1 claim. [Cl. 19-8.] The process of application to bagasse and the like is essentially a screening process for recovering pith-free fibers for papermaking.

Peyrebrune, Henri E. Multiple sheet feeder. U. S. patent 2,906,528. Filed Nov. 21, 1957. 6 claims. Assigned to Miehle-Goss-Dexter, Inc. [Cl. 271-10.] A printing machine feeder feeds a number of checks, cards, or the like at the same time from several supply stacks.

Polkosnik, Bernard L. Label inserting apparatus. U. S. patent 2,906,425. Filed Oct. 2, 1958. 5 claims. Assigned to Ever Ready Calender Mfg. Co. [Cl. 216-9.] The label is inserted into a wrapped pack containing a calendar pad refill.

Reeves, Wilson A., Guthrie, John D., and Drake, George L., Jr. Flame- and crease-resistant textiles from aziridine carboxyalkylcellulose. U. S. patent 2,906,592. Filed Aug. 20, 1957. 7 claims. Assigned to The Secretary of Agriculture. [Cl. 8-116.2.]

Robinson, Joseph J., Jr., and Story, Charles F. Process for humidifying hardboard. U. S. patent 2,906,034. Filed March 15, 1957. 8 claims. Assigned to Masonite Corp. [Cl. 34-26.]

Santuci, Robert L., Sr. Cereal canister. U. S. patent 2,906,439. Filed May 3, 1957. 1 claim. [Cl. 222-183.] The canister holds and dispenses cereal from a paperboard box.

Schmidt, Erich, Reichenhall, Bad, Mossmüller, Fritz, and Schnegg, Robert. Process of improving dyeing properties of cellulose, cellulose esters and esters by reaction with a carbodiimide compound employing a copper salt catalyst. U. S. patent 2,906,749. Filed Aug. 16, 1955. 1 claim. Assigned to Farbenfabriken Bayer A. G. [Cl. 260-231.]

Simmons, Vaughan P. Divided label-lift. U. S. patent 2,906,397. Filed Nov. 4, 1957. 11 claims. Assigned to W. H. Brady Co. [Cl. 206-56.] A backing card for pressure-sensitive labels is designed to facilitate lifting the labels from the card.

Sisson, Wayne A. Method of producing viscose rayon. U. S. patent 2,906,634. Filed July 2, 1957. (Divided; original Nov. 3, 1954.) 5 claims. Assigned to American Viscose Corp. [Cl. 106-165.] The coagulation modifiers used are alkylene oxide adducts of urea and biuret.

Smith, Donald P., Rollin, Joseph N., and James, Albert L. Food preserving wrapping material and process of preparing the same. U. S. patent 2,906,646. Filed Feb. 15, 1954. 15 claims. Assigned to Milprint, Inc. [Cl. 117-144.] The fungistatic material comprises cellophane or the like coated with a waxy or rubbery material in which is embedded particles of sorbic acid.

Springer, Donald A. Rubber band dispenser. U. S. patent 2,906,398. Filed April 3, 1958. 3 claims. [Cl. 206-56.] An envelope for rubber bands has a hole through which the bands may be dispensed.

Tabakof, Allen B., and Pitt, Herman V. Packing carton liner for sensitive instruments. U. S. patent 2,906,445. Filed Sept. 9, 1957. 7 claims. [Cl. 229-14.]

Walker, Bernard F., Ward, Raymond C., and Godehn, Donald J. Viscose spinning device. U. S. patent 2,905,968. Filed Sept. 7, 1955. 2 claims. Assigned to American Enka Corp. [Cl. 18-8.] A spinneret shield is provided.

Weiss, Arthur J., and Stone, Orison W., and Doran, Donald P. Hinged cover paperboard carton and blank therefor. U. S. patent 2,906,444. Filed May 25, 1956. 3 claims. Assigned to Continental Can Co., Inc. [Cl. 229-14.] This is a flip-top cigarette box.

Williams, Russell J. Bag. U. S. patent 2,906,446. Filed Aug. 18, 1958. 8 claims. Assigned to Bemis Bro. Bag Co. [Cl. 229-62.5.] An improved valve and sleeve construction is in a pasted valve bag of the type used in packaging fertilizer.

The following patents were received later than those of the same issue date and have accumulated during the past quarter.

October 28, 1958

Brown, George E., Jr. Stable completely oxidized macromolecular composition. U. S. patent 2,858,238. Filed April 26, 1955. 15 claims. [Cl. 117-164.] A proteinaceous composition is prepared and used in treating paper to improve tensile strength and resistance to fire, water, and chemicals.

November 4, 1958

Harvey, Mortimer T., and Rosamilia, Peter L. Combinations of vinyl aqueous emulsions and resinous acetone-formaldehyde reaction products. U. S. patent 2,859,192. Filed Sept. 22, 1955. 8 claims. Assigned to Harvel Research Corp. [Cl. 260-29.6.] These are laminating agents for paper and board.

December 23, 1958

McKnight, George S., Jr., and Brown, Robert C. Coating compositions. U. S. patent 2,865,773. Filed June 25, 1954. 9 claims. Assigned to Oxford Paper Co. [Cl. 106-154.] The composition is for use in making machine-coated offset paper.

January 13, 1959

Johnson, Gordon C., and Jellinek, Maurice H. Method of curing silicone water repellents with cyclopentadienyl transition element catalysts and aqueous compositions of same. U. S. patent 2,868,751. Filed Jan. 18, 1956. 14 claims. Assigned to Union Carbide Corp. [Cl. 260-29.2] The silicones may be used in improving the water-repellency of paper.

February 24, 1959

Bollenback, Carol H., and Johnson, Carl E. Chemical compositions. U. S. patent 2,875,210. Filed May 17, 1956. 5 claims. Assigned to National Aluminate Corp. [Cl. 260-309.6.] Quaternized imidazolines are used as paper pulp microbicides.

April 28, 1959

Neukom, Hans. Phosphate-modified starches and preparation. U. S. patent 2,884,412. Filed Sept. 4, 1953. 17 claims. Assigned to International Minerals & Chem. Corp. [Cl. 260-

233.5.] The starch phosphates provided are of use as beater additives, in sizing, and in other applications.

May 12, 1959

Langlois, David P., and Pinney, George C. Method of preparing an adhesive which comprises reacting an amylaceous material, a phenol and an aldehyde. U. S. patent 2,886,541. Filed June 8, 1955. 6 claims. Assigned to A. E. Staley Mfg. Co. [Cl. 260-17.2.] The adhesive is for use in making laminated and corrugated paperboard.

McNaughtan, Thomas J., Lieb, David J., and Boschert, Ulrich. Phenolformaldehyde-ketone condensate and starch composition. U. S. patent 2,886,540. Filed June 3, 1955. 1 claim. [Cl. 260-17.2] This is a quick-setting water-resistant starch-base adhesive for use in making corrugated board.

May 26, 1959

Little, Ernest L., and Whitman, Gerald M. Preparation of long-chain alkylhalosilanes. U. S. patent 2,888,476. Filed Aug. 1, 1956. 10 claims. Assigned to E. I. du Pont de Nemours and Co. [Cl. 260-448.2.] These products are of use in waterproofing paper.

Pleuddemann, Edwin P. Titanated alkoxy silanes. U. S. patent 2,888,475. Filed March 4, 1953. 10 claims. Assigned to Allied Chem. Corp. [Cl. 260-429.5.] A titanium salt is reacted with an alkoxysilane to produce a silyl titanate of use in waterproofing paper.

June 9, 1959

Kress, Bernard H. Amine modified acetals. U. S. patent 2,890,242. Filed Sept. 14, 1955. 8 claims. Assigned to Quaker Chem. Prods. Corp. [Cl. 260-501.] These acetals are of use in imparting wet strength and dimensional stability to paper and the like.

June 23, 1959

Pontius, Eugene C. Viscose process. U. S. patent 2,891,-836. Filed April 26, 1955. 8 claims. Assigned to E. I. du Pont de Nemours and Co. [Cl. 18-54.] The coagulation modifier is sodium N-methylcyclohexyldithiocarbamate.

Vallas, Charles L. Spirally wound container tube. U. S. patent 2,891,714. Filed March 12, 1956. 1 claim. Assigned to Cleveland Container Co. [Cl. 229-51.] Improved opening means are provided in a container for pressure-packed bakery products.

June 30, 1959

Ross, Sidney D. Capacitors. U. S. patent 2,892,972. Filed Sept. 10, 1954. 7 claims. Assigned to Sprague Electric Co. [Cl. 317-258.] An impregnated paper spacing element is provided.

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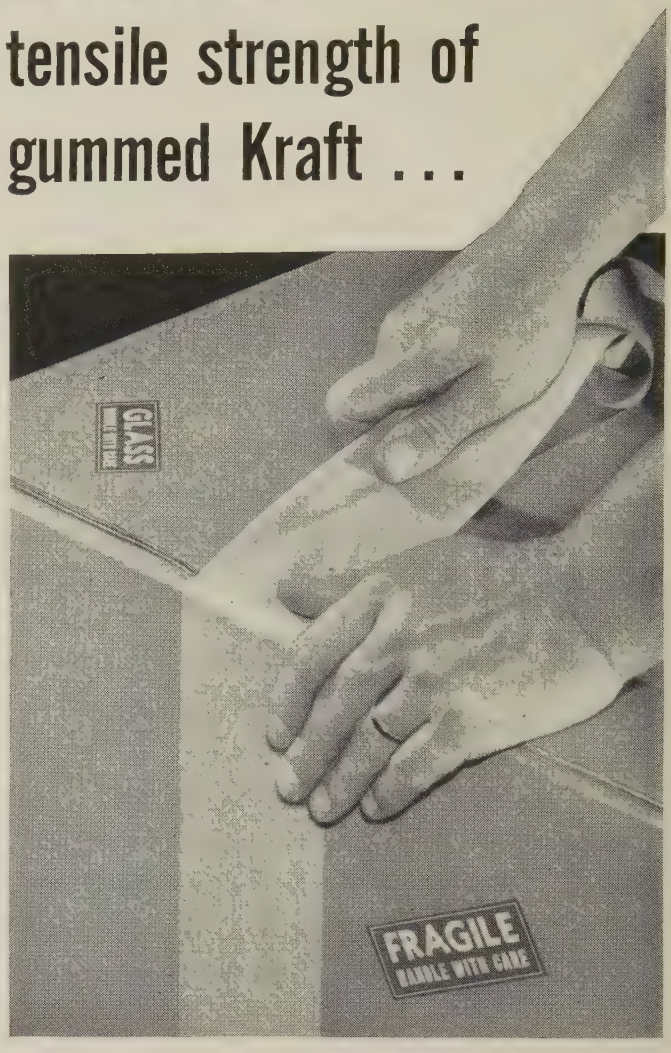

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